Journal of Medical Research and Health Sciences
Received 10 June 2022 | Revised 25 June 2022 | Accepted 25 July 2022 | Published Online 10 Aug 2022

DOI: https://doi.org/10.52845/JMRHS/2022-5-8-3

JMRHS 5 (8), 2145–2152 (2022)

ISSN (O) 2589-9031 | (P) 2589-9023

Research Article

Open Access Journal

Analytical Implication of Cardiac Biomarkers in Patients with Acute Ischemic Stroke: A Cross-Section Study

Dheyaa Kadhim Hassoon Al-Khafaji [*1], Khalid Yahia Hammed Al-Quzwiny [2], Qasim Jawad Al-Daami [3]

Corresponding author: Dheyaa Kadhim Hassoon Al-Khafaji

[1]FICMS., (Med.), Babylon Health Directorate, Babylon ,Iraq.
[2]MD, (Med.), Merjan Teaching Medical City, Babylon Health Directorate, Babylon, Iraq.
[3]Dep. of Pharmaceutical Chemistry, College of Pharmacy, University of Babylon.

Abstract

Background: Quite a lot of articles have been printed confirming the central nervous system's role in regulating the heart and hence ECG morphology. There are conflicting outcomes on the likely role of cardiac troponin (CT) and creatine kinase (CK) in stroke patients. Raised cardiac enzymes during stroke probably as a thrombo-embolic sequel of the initial cardiac injury or the cardiac injury could be a sequel to the initial stroke. This study was intended to evaluate the prognostic implication of CT-T and CK-MB in patients with acute ischemic stroke (AIS).

Material and methods: This single-center cross-sectional study included seventy inpatients admitted with acute ischemic stroke (AIS). History, 12-leads-ECG, and blood sampling for CT-T and CK-MB levels were performed for all candidates. Then, these variables were analyzed based on the stroke severity that was assessed using Scandinavian Stroke Scale (SSS) and on the in-hospital short-term fate (death or survival) registered. SPSS was the referenced software for the statistical analysis.

Results: the mean age of AIS patients was 60 years (range of 35-85) with a preponderance of males 46 (65.7%). Minority of patients revealed CT-T levels > 0.035ng/ml (22.9%) and CK-MB> 25IU/L (35.7%). Abnormal ECG findings were observed in < 50% of the patients and in m<2/3rd of them the SSS were > 20, with a survival rate of (81.4%). There was more serum CT-T elevation among the patient group with abnormal ECG, more stroke severity, and in-hospital death (p>0.05). While there was a non-significant association (p>0.05) of elevated CK-MB levels with ECG abnormalities, stroke severity, and in-hospital death.

Conclusion: There were higher CT-T serum levels among AIS patients, which can result from skeletal muscles, neurological, or cardiac origins. Raised CT-T levels were associated with stroke severity and in-hospital mortality and in combination with (ischemic-like) ECG changes in DM or hypertensive patients may point toward asymptomatic myocardial injury that warrants attention among those with positive CT-T measures. Meanwhile, the raised CK-MB level was not associated with abnormalities, stroke severity, in-hospital mortality, and possibly of non-cardiac origin.

Keywords: Troponin-T, CK-MB, stroke, ischemic heart diseases, myocardial infarction, death, ECG.

Introduction

Though still debatable, the clinical and observational research has shown associations between cardiac ischemia and numerous biomarkers such as C-reactive protein [1-3], atrial natriuretic peptides [4], cystatin-C [5], troponins [4, 6], uric acids [7], creatine-kinase (CK) [8], and others. As crucial for various cellular energy metabolism, the CK enzyme expresses extensively in tissues, particularly in tissues of muscle and brain. There are three CK isozymes, which are tissue-specific (CK-BB, CK-MB, and CK-MM) in the cytoplasm [9]. While the CK-BB isozyme exists primarily in the brain, the CK-MB in the cardiac muscles, and CK-BB in the skeletal muscles. CK and/or CK isozymes were shown to be raised in cerebrovascular accidents (CVA) or stroke, myopathies, and myocardial injuries, and were applied as biomarkers of tissue damage [10]. Stroke is a term used to describe a disorder of sudden onset of neurological deficits resulting from changed vascularity, triggering ischemia or hemorrhage, resulting in variable loss of brain activities [11].

Early detection of stroke-related conditions may help to eliminate lethality and improve the outcomes. Central nervous system (CNS) metabolic variations have long been known to impact cardiac activities [12]. Quite a lot of articles have been printed confirming the hypothalamic role in regulating heart rhythm. Morphological electrocardiogram (ECG) changes of repolarization type occur when the hypothalamus and other parts of the brain are stimulated experimentally [13].

In clinical practice, cardiologists often encounter biomarkers of myocardial ischemia and ECG changes are associated with prognosis in patients with stroke [14]. The most popular cardiac marker in patients with stroke is troponin. The “2015 American Heart Association/American Stroke Association guidelines” acclaim cardiac work-up of cases with spontaneous cerebral bleeding, including both troponin and ECG, to evaluate active myocardial ischemia [15]. Cardiac troponins-I and T (CT-I and CT-T) are recent biomarkers of myocardial damage with high specificity and sensitivity [4, 11, 16, 17].

Nevertheless, there are conflicting outcomes on the likely role of CT-T in stroke patients. Raised cardiac enzymes during stroke probably as a thrombo-embolic sequel of the initial cardiac injury or the cardiac injury could be a sequel to the initial stroke [18].

This study was intended to evaluate the prognostic implication of CT-T and CK-MB in patients with acute ischemic stroke.

Patients and methods

Study design and sampling

This single-center cross-sectional study included seventy stroke patients and was conducted from April to October 2021. All patients diagnosed with acute ischemic stroke (AIS) by the neurologists in Merjan Teaching Medical City were enrolled consecutively and prospectively in this study. The diagnosis of AIS was based on a history of any neurological deficit, general and neurological examination, as well as brain imaging (CT or MRI scanning).

Data from the patients regarding the previous history of previous stroke, diabetes, hypertension, and tobacco smoke, were recorded also.

The exclusion criteria included any condition that may increase serum CT-T levels rather than strokes, like myocardial ischemia or failure and a history of cardiac surgery or catheterization.

Electrocardiography

Twelve lead ECGs were recorded for all the patients at admission on the first day of admission, interpreted by a cardiologist, and classified into normal and pathological based on the modified Minnesota code [19].

Venous blood drains were investigated for CT-T and CK-MB from all participants (after 12-24 hours of admission). CT-T was measured by the VIDAS immunoassay kit (Biomeruex®, France). While Ck-MB has been measured by spectrophotometric assay kit (Biolabo®, France).

Statistical analysis

The serum measures of CT-T were classified as high (>0.035), or normal (≤0.035) ng/ml as "the European Society of Cardiology and American College of Cardiology" commend 0.035 ng/ml as the CT-T cutoff value for the diagnosis of cardiac injury [20]. Likewise, CK-MB readings were classified also into high (>25) and normal (≤25) IU/L. The severity of AIS was evaluated by "The Scandinavian Stroke Scale (SSS)", accordingly, AIS patients were divided into severe (SSS >20) and less severe (SSS≤ 20). The Chi-square test was used to study the correlation between the parameters. P-value <0.05 is significant. SPSS-version-15 was utilized to analyze the statistical results.

Results

A total of 70 patients with AIS were registered in the study, with a preponderance of males 46 (65.7%), and a mean age of 60 years old (range of 35-85years). The mean duration of admission was 4 days (range 3-7days). Minority of AIS patients revealed CT-T levels > 0.035ng/ml (22.9%) and CK-MB> 25IU/L (35.7%). Abnormal ECG findings were observed in less than half of the AIS patients, and in more than two third of them the SSS were > 20. Hypertension was present in 47.1%, while 18.6% were diabetic. The survival rate of AIS patients in this study was very good (81.4%), (Table 1).

Table-1: basal characteristics of the included stroke patients (N-70)

Variables	**Descriptive Statistics**	
Gender N (%)	Male	46 (65.7%)
	Females	24 (34.3%)
Age/years (Mean± SD)		60 ± 8.2
Duration of admission (Mean ± SD)		4±2.1/days
CT-T (ng/ml)	Normal (< 0.035)	54 (77.1%)
	High (> 0.035)	16 (22.9%)
CK-MB (IU/L)	Normal (≤25)	45 (64.3%)
	High (>25)	25 (35.7%)
ECG Findings*	Normal	38 (54.3%)
	Abnormal	32 (45.7%)
Scandinavian stroke scale	> 20	48 (68.6%)
	≤ 20	22 (31.4%)
Hypertension	Positive	33 (47.1%)
	Negative	37 (52.9%)
Diabetes mellitus	Positive	13 (18.6%)
	Negative	57 (81.4%)
In hospital fate	Survived	64 (81.4%)
	Dead	6 (8.6%)

* ECG findings include (ST segment, T wave, AV conduction, Ventricular conduction) abnormalities, and/or AF, based on a modified version of the Minnesota code.

Table 2 revealed a significant association of CT-T classes with the presence or absence of ECG abnormalities. There was more serum CT-T elevation among the patient group with abnormal ECG. While there was a non-significant association of CK-MB levels with ECG abnormalities.

Table 2: Association of the classes of CT-T and CK-MB with the electrocardiographic abnormalities

	No ECG changes	**ECG changes**	**Total**	**P-value**
CT-T ≤ 0.035 (ng/ml)	36 (94.7%)	18 (56.2%)	54 (77.1%)	0.01
CT-T > 0.035 (ng/ml)	2 (5.3%)	14 (43.8%)	16 (22.9%)	

CK-MB ≤ 25 (IU/L)	25 (55.6%)	20 (44.4%)	45	> 0.05
CK-MB > 25 (IU/L)	13 (52%)	12 (48%)	25	

The stroke severity was greater significantly (p-0.05) in patients with elevated serum CT-T group (> 0.035ng/ml). There was no association of the stroke severity with CK-MB classes, (Table 3).

Table 3: Association of the classes of CT-T and CK-MB with the classes of the Scandinavian stroke scale

	SSS > 20	**SSS ≤ 20**	**Total**	**P -value**
CT-T ≤ 0.035 (ng/ml)	43 (89.6%)	11 (50.0%)	54 (77.1%)	0.05
CT-T > 0.035 (ng/ml)	5 (10.4%)	11 (50.0%)	16 (22.9%)	
CK-MB ≤ 25 (IU/L)	31 (64.6%)	14 (63.6%)	45 (64.3%)	> 0.05
CK-MB > 25 (IU/L)	17 (35.4%)	8 (36.4%)	25 (35.7%0	

There was a significant correlation between patients with elevated CT-T levels with in-hospital death (p-0.05), which was not the case for the correlation of CK-MB levels with in-hospital mortality (p> 0.05), (Table 4).

Table 4: Distribution of the classes of CT-T and CK-MB according to the in-hospital fate (survived or dead)

	Survived	**Dead**	**Total**	**P-value**
CT-T ≤ 0.035 (ng/ml)	52 (81.2%)	2 (33.3%)	54 (77.1%)	0.05
CT-T > 0.035 (ng/ml)	21 (18.8%)	4 (66.7%0	16 (22.9%)	
CK-MB ≤ 25 (IU/L)	40 (62.5%)	5 (83.3%)	45 (64.3%)	> 0.05
CK-MB > 25 (IU/L)	24 (37.5%)	1 (16.7%)	25 (53.7%)	

There is no analogous correlation between serum CT-T elevations with increased serum CK-MB. Serum CK-MB was not increased in most of the AIS patients, which showed higher CT-T serum levels, instead, it increased mainly in patients with normal CT-T blood levels (Table 5).

Table 5: Association of the CT-T with the CK-MB among the studied stroke patients

	CK-MB ≤ 25 (IU/L)	**CK-MB > 25 (IU/L)**	**Total**	**P-value**
CT-T ≤ 0.035 (ng/ml)	36 (80.0%0	18 (72.0%)	54 (77.1%)	> 0.05
CT-T > 0.035 (ng/ml)	9 (20.0%)	7 (28.0%)	16 (22.9%)	

Discussion

Though this study was not the first in Iraq that inspect the levels of circulating CT-T and CK-MB among patients with AIS, however, it was the first to assess their prognostic ability in stroke patients. The study concluded that the changes in cardiac biomarkers and ECG in patients with AIS can to some extent enlighten and predict the in-hospital fate.

The main outcomes of the current study were the association of elevated serum CT-T (but not CK-MB serum levels) with abnormal ECG, more

stroke severity, and more in-hospital death. There have been several experimental, and interventional trials inspecting the link between cardiac biomarkers and CVAs [10-12, 14]. An increasing body of literature supports, though it is not conclusive, the outcomes of the current study. In a Nigerian case-control prior study, Suleiman HM. et al. found that the mean plasma CT-T and CK-MB levels were greater in AIS patients compared to the controls and concluded that plasma levels of CT-T are a significant marker of the severity of AIS [21]. Bogarapu K. et al. suggested that stroke patients have elevated serum CK-MB values that do not inevitably specify coronary ischemia [22]. Along similar veins, a systematic review deduced that high CT-T levels after AIS are common, related to ECG abnormalities indicative of cardiac injuries, and increased mortality risk [23].

As a rebuttal to this view, it might be argued that not only is the basis of increased CT-T levels indistinct, but as well its scientific implication. Some revisions have described an independent correlation of CT-T with both death and the poor outcome [23]. Still, other scholars have revealed that CT-T was not an independent prognosticator of mortality [24].

The precise mechanism of cardio-cerebral association is indefinite; still, scientists ascribed it to the central sympathetic activation due to damage to the insular cortex [24], resulting in a cardiac consequences like cardiomyocyte injuries, increased serum enzymes, and arrhythmias are known to develop in some cases of CVAs [21]. High concentrations of catecholamines in the heart cause calcium overload in cardiomyocytes that inhibit cardiac contractility owing to the disturbed capillary perfusion resulting from enhanced platelet aggregation [25]. Yet, the experimental results of insular involvement are still unreliable, and some studies did not expose a difference in ECG or blood cardiac enzyme effects between left and right cerebral hematoma [13]. One possible explanation is the central regulation of the sympathetic system was not only in the insular cortex, but also cingulate gyrus, amygdala, and hypothalamus [26]. Central cardiac autonomic centers may also include the extra-insular regions and their interconnecting fibers [27].

The physiological role of CK is to catalyze the reaction between creatine and ATP to produce creatine phosphate and ADP, which are vital for cellular energy metabolism. Several reports disclosed increased serum CK-MB values in patients with AIS [10, 22, 28], but the causes remained debated. Many academics assumed that elevated serum CK levels following AIS perhaps initiated from skeletal muscles instead of cardiac muscles or brain tissue [29]. The brain neurons have the CK-BB subunit; this may also elucidate the probable secondary high CK-MB caused by brain damage [30]. Nevertheless, the manifestation of AIS was not typically associated with significant CT-T elevation and ultimate diagnosis of myocardial injuries [4, 31]. Hence, elevated CK-MB and ECG changes after AIS could be neurogenic rather than cardiac in origin.

Supporting the outcomes of the present study, a preceding study showed that high CK-MB was not significantly associated with stroke recurrence and outcomes [10, 29]. This discrepancy might be due to the detection timing of AIS, site of brain infarction, and degree of brain tissue or blood-brain barrier injury [32].

Tumor-necrosis-factor (TNF) is a lympho-cytokine that has a crucial role in chronic inflammation [33, 34]. TNF and CK-MB were found to be independent predictors of mortality in patients with myocardial ischemia [35]. Furthermore, studies have exposed that the evolution and outcome of AIS are influenced by a complex association of the blood-brain barrier with TNFα [36]. In these backgrounds, TNF seems to share a mutual role in AIS and myocardial ischemia, though the precise mechanism is unclear.

In the current study, the incidence of ECG changes in AIS can be elucidated by neural and cardiac causes [32, 37]. The neural cause was ascribed, to raised intracranial pressure and insular injury and mainly rhythm and conductive irregularity in nature [32]. Whereas the heart causes of ECG variations resulted from cardiac injury, which is owing to the stress exerted by catecholamine release and/or associated

asymptomatic heart disease, which also resulted from the stress exerted by AIS and ensuing acute coronary syndrome. The ECG abnormalities here, are more likely ischemic-like changes [32, 38].

In the present study, a significant association ($P<0.05$) of high CT-T with stroke severity was concluded and can be reinforced by the magnitude and importance of brain zones involved by AIS. As well, the study showed a significant relationship ($P<0.05$) between high CT-T with in-hospital death, which was supported by other researchers [39]. The latter could be clarified by the fact that every CVA is probable to exert substantial cardiac stress on the patients [22]. Subjects with primary asymptomatic heart disease, especially atherosclerosis, probably show a decrease in pre-stroke contractile function. Hence, raised CT-T may reflect subnormal myocardial tolerance to stress induced by CVAs [23]. Another potential explanation is a pre-existing cardiac event caused the subsequent AIS [39].

Consistent with other studies, there were significant relationships between elevated CT-T with hypertension and DM in this study. This can be explained by the high prevalence of underlying coronary sclerosis in patients with DM or hypertension [11, 21, 22].

Pathologically, AIS-related myocardial ischemia is characterized by dispersed focal lesions [40], thus CT-T may exceed the cutoff reading (0.035ng/ml) with these minor quantities of injured tissues. Whereas CK-MB usually remains normal. Given this potent sensitivity of CT-T in focal cardiac tissue injuries, CT-T levels above the cutoff limit in stroke patients with suspected cardiac damage are anticipated. However, in the present work, the patients with AIS showed that CT-T did not exceed the cutoff in most CK-MB positive cases. Accordingly raised CK-MB values detected in stroke patients did not reflect stroke-related cardiac injuries. The source of the raised CK-MB levels remains to be explained.

Alternatively, normal CT-T accompanied by high CK-MB levels proposes that probably the elevated CK-MB was of non-cardiac origin [31]. The latter could include muscular injuries from injection sites, adverse caloric setting, or a cardiac origin but the raise reaches the measures of myocardial ischemia and is equivalent to raised CT-T. Given the expected non-cardiac CK-MB sources, it poorly correlates with stroke severity and in-hospital mortality.

The authors found that the measures of serum CT-T are imperative in a patient with AIS, to eliminate concomitant asymptomatic myocardial ischemia, especially when ischemic-like ECG changes and/or other risk factors were present.

Conclusion

There were higher CT-T serum levels among AIS patients, which can result from skeletal muscles, neurological, or cardiac origins. Raised CT-T levels were associated with stroke severity and in-hospital mortality and in combination with (ischemic-like) ECG changes in DM or hypertensive patients may point toward asymptomatic myocardial injury that warrants attention among those with positive CT-T measures. Meanwhile, the raised CK-MB level was not associated with ECG abnormalities, stroke severity, as well as in-hospital mortality, and possibly of non-cardiac origin.

References:

1. Asseel K. Shaker, R.A.-S., Raad Jasim, Hayder Abdul-Amir Makki Al-Hindy, Biochemical Significance of Cystatin-C and High Sensitive CRP in Patients with Acute Coronary Syndrome; any Clinical Correlation with Diagnosis and Ejection Fraction. Sys Rev Pharm, 2020. 11(3): p. 8.
2. Hajir Karim Abdul-Husseein, F.S.D., Ameera Jasim Al-Aaraji, Hayder Abdul-Amir Makki Al-Hindy, Mazin Jaafar Mousa, Biochemical causal-effect of circulatory uric acid, and HSCRP and their diagnostic correlation in admitted patients with ischemic heart diseases. Journal of Cardiovascular Disease Research 2020. 11(2): p. 25-31.
3. Hayder Abdul-Amir Maki Al-Hindi, M.J.M., Thekra Abid Jaber Al-kashwan, Ahmed Sudan, Saja Ahmed Abdul-Razzaq, On Admission Levels of High Sensitive C-Reactive Protein as A Biomarker in Acute Myocardial Infarction: A Case-Control Study.

Indian Journal of Public Health Research & Development 2019. 10(4): p. 5.
4. Amir Al-Mumin, H.A.-A.M.A.-H., Mazin JM., Combined Assessments of Multi-panel Biomarkers for Diagnostic Performance in Coronary Artery Disease: Case-Control Analysis. Sys Rev Pharm, 2020. 11(6): p. 7.
5. Abed, D.A., Jasim Raad, Hayder Abdul-Amir Al-Hindy, Ammar Waheeb Obaid Cystatin-C in patients with acute coronary syndrome: Correlation with ventricular dysfunction, and affected coronary vessels. Journal of Contemporary Medical Sciences, 2020. 6(1): p. 26-31.
6. Hayder Abdul- Amir Maki Al-Hindi, S.F.A.-S., Basim MH Zwain, Thekra Abid Al-Kashwan Jaber, Relationship of Salivary & Plasma Troponin Levels of Patients with AMI in Merjan medical city of Babylon Province: Cross-Sectional Clinical Study. Al-Kufa University Journal for Biology, 2016. 8(3): p. 53-58.
7. Hayder Abdul-Amir Maki Al-Hindi, M.J.M., Thekra Abid Jaber Al-Kashwan, Ahmed Sudan, Saja Ahmed Abdul-Razzaq, Correlation of on Admission Levels of Serum Uric Acid with Acute Myocardial Infarction: Case: Control Study. Journal of Global Pharma Technology, 2019. 11(7): p. 6.
8. Zaha, V.G., et al., Future Perspectives of Cardiovascular Biomarker Utilization in Cancer Survivors: A Scientific Statement From the American Heart Association. Circulation, 2021. 144(25): p. e551-e563.
9. Tsung, S.H., Creatine kinase isoenzyme patterns in human tissue obtained at surgery. Clin Chem, 1976. 22(2): p. 173-5.
10. Li, S., et al., Creatine Kinase Is Associated With Recurrent Stroke and Functional Outcomes of Ischemic Stroke or Transient Ischemic Attack. J Am Heart Assoc, 2022. 11(6): p. e022279.
11. Radhakrishnan, S., et al., Role of Cardiac Biomarkers in the Assessment of Acute Cerebrovascular Accident. Journal of Neurosciences in Rural Practice, 2021. 12: p. 106-111.
12. Srinivasan Radhakrishnan, S.M., Sudish Gadde, Krishnaswamy Madhavan, Role of Cardiac Biomarkers in the Assessment of Acute Cerebrovascular Accident. J Neurosci Rural Pract, 2021. 12(1): p. 106–111.
13. Qin, G., et al., Changes of Electrocardiogram and Myocardial Enzymes in Patients with Intracerebral Hemorrhage. Disease Markers, 2022. 2022: p. 9309444.
14. He, Y., et al., Prognostic value of elevated cardiac troponin I in patients with intracerebral hemorrhage. J Clinical cardiology, 2020. 43(4): p. 338-345.
15. Morgenstern, L.B., et al., Guidelines for the management of spontaneous intracerebral hemorrhage: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. J Stroke, 2010. 41(9): p. 2108-2129.
16. Raghdan Z., A.K.S., Dleikh F., Al-Hindy H., Is There any Association Between Highly Sensitive C-Reactive Protein and Dental-Status in Ischemic Heart Diseases? A Comparative Stud. Biochemical and Cellular Archives, 2020. 20(2): p. 6069-6075.
17. Samer MM., A.S., Hayder AA., Mazin JM., C-Reactive Protein is Associated with the Severity of Periodontal Disease — An Observational Study Among Acute Myocardial Infarction Patients. Sys Rev Pharm 2020. 11(10): p. 252-257.
18. Dixit, S., et al., Cardiac involvement in patients with acute neurologic disease: confirmation with cardiac troponin I. Arch Intern Med, 2000. 160(20): p. 3153-8.
19. Blackburn, H., et al., The electrocardiogram in population studies. A classification system. Circulation, 1960. 21: p. 1160-75.
20. Alpert JS, T.K., Antman E, Bassand JP., Myocardial infarction redefined-a consensus document of the joint European society of cardiology/ American College of Cardiology Committee for redefinition of myocardial infarction. J Am Coll Cardiol., 2000. 36: p. 959-969.
21. Suleiman, H.M., et al., Cardiac Troponin T and creatine kinase MB fraction levels among patients with acute ischemic stroke in Nigeria. Niger J Clin Pract, 2017. 20(12): p. 1618-1621.

22. Kiranmayi, B., V. Bhavani, and R. Tagore. Evaluation of CK MB levels in Acute Ischemic stroke. 2015.
23. Kerr, G., et al., Elevated troponin after stroke: a systematic review. Cerebrovasc Dis, 2009. 28(3): p. 220-6.
24. Barber, M., et al., Elevated troponin levels are associated with sympathoadrenal activation in acute ischaemic stroke. Cerebrovasc Dis, 2007. 23(4): p. 260-6.
25. Sheyin, O., et al., The prognostic significance of troponin elevation in patients with sepsis: a meta-analysis. Heart Lung, 2015. 44(1): p. 75-81.
26. De Raedt, S., A. De Vos, and J.J.J.o.t.n.s. De Keyser, Autonomic dysfunction in acute ischemic stroke: an underexplored therapeutic area? 2015. 348(1-2): p. 24-34.
27. Dütsch, M., et al., Cardiovascular autonomic function in poststroke patients. 2007. 69(24): p. 2249-2255.
28. Mohamed, W.S., et al., Cardio embolic stroke and blood biomarkers: diagnosis and predictors of short-term outcome. The Egyptian Journal of Neurology, Psychiatry and Neurosurgery, 2019. 55(1): p. 68.
29. Norris, J.W., et al., Serum cardiac enzymes in stroke. Stroke, 1979. 10(5): p. 548-53.
30. Bell, R.D., et al., Quantification of cerebral infarct size by creatine kinase BB isoenzyme. Stroke, 1986. 17(2): p. 254-60.
31. Ay, H., E.M. Arsava, and O. Saribaş, Creatine kinase-MB elevation after stroke is not cardiac in origin: comparison with troponin T levels. Stroke, 2002. 33(1): p. 286-9.
32. Togha, M., et al., Electrocardiographic abnormalities in acute cerebrovascular events in patients with/without cardiovascular disease. Ann Indian Acad Neurol, 2013. 16(1): p. 66-71.
33. Hayder Abdul-Amir Alhindy and Mazin J. Mousa Enas K. Alkhazraji, A.A.A., Mahir Abdulkhadhum Alzughaibi, Positive correlation of circulating tumor necrosis factor-alpha (TNFα) with spirometric pulmonary tests in adult asthmatic patients. Biochem. Cell. Arch., 2021. 21: p. 2605-2610.
34. Ahmed Khalid Aldhalmi, A.J.H.A.-A., Hayder Abdul-Amir Makki Al-Hindy, Association of Tumor Necrosis Factor-α and Myeloperoxidase enzyme with Severe Asthma: A comparative study. Reports of Biochemistry & Molecular Biology, 2022. 11(238-245).
35. Valgimigli, M., et al., Tumor necrosis factor-alpha receptor 1 is a major predictor of mortality and new-onset heart failure in patients with acute myocardial infarction: the Cytokine-Activation and Long-Term Prognosis in Myocardial Infarction (C-ALPHA) study. Circulation, 2005. 111(7): p. 863-70.
36. Pan, W., and A.J. Kastin, Tumor necrosis factor, and stroke: role of the blood-brain barrier. Prog Neurobiol, 2007. 83(6): p. 363-74.
37. Weinberg, S.J. and J.M. Fuster, Electrocardiographic changes produced by localized hypothalamic stimulations. Ann Intern Med, 1960. 53: p. 332-41.
38. Fure, B., T. Bruun Wyller, and B. Thommessen, Electrocardiographic and troponin T changes in acute ischaemic stroke. J Intern Med, 2006. 259(6): p. 592-7.
39. James, P., et al., Relation between troponin T concentration and mortality in patients presenting with an acute stroke: observational study. BMJ, 2000. 320(7248): p. 1502-4.
40. Connor, R.C., Heart damage associated with intracranial lesions. Br Med J, 1968. 3(5609): p. 29-31.

How to Cite : Al-Khafaji, D. K. H. ., Al-Quzwiny, K. Y. H. ., & Al-Daami, Q. J. . (2022). Analytical Implication of Cardiac Biomarkers in Patients with Acute Ischemic Stroke: A Cross-Section Study . Journal of Medical Research and Health Sciences, 5(8), 2145–2152. https://doi.org/10.52845/JMRHS/2022-5-8-3