Serum Low Density Lipoprotein and Serum High Sensitive C - Reactive Protein as a Diagnostic Markers for Acute Coronary Syndrome

Samia A. Sadek Elsbai *, Zeinab H. EL-sayed *, Karima Y. Ahmed *, Nagwa A. Ghaffar Mohamedand Naglaa S. El-Kholy *.**

Departments of Internal Medicine, Al-Azhar Faculty of Medicine (Girls)*, and of Clinical and Chemical Pathology, National Research Center**, Cairo, Egypt.

ABSTRACT

Background: Acute coronary syndrome (ACS) remains the major cause of mortality and morbidity in the worldwide. Low density lipoprotein- cholesterol (LDL-C) level is a major risk factor for the development of ACS, and pathogenesis of atherosclerosis. Atherosclerosis is a multi-step disease and characterized by chronic low-grade vascular inflammation, which plays a role in its every stage from onset, progression and finally to plaque rupture then triggers ACS. Elevation of high Sensitive C-reactive protein (hs-CRP) is a strong and independent predictor of cardiovascular disease.

The objective of this work was to evaluate the role of serum LDL-C and serum hs-CRP in patients with ACS.

Patients and Method: The current study enrolled 45 patients with confirmed ACS and 30 apparently healthy persons of matching age and sex as control group. The patients were subdivided into three subgroups each one included 15 patients: Subgroup A: ST-segment elevation myocardial infarction (STEMI). Sub-group B: Non–ST-segment elevation myocardial infarction (NSTEMI), Subgroup C: Unstable angina pectoris (UAP). All patients and control groups were subjected to measurement of low density lipoprotein- cholesterol (LDL-C), high density lipoprotein- cholesterol (HDL-C), total cholesterol, triglyceride, highly sensitive CRP (hs-CRP), cardiac troponin I (cTnI), and creatine kinase-MB fraction (CK-MB), electrocardiography (ECG) and trans-thoracic-echocardiography.

Results: There was highly significant increase of serum LDL-C and serum hs-CRP in group I as compared to group II (P=0.001) and significant increase of serum LDL-C ((P<0.05) and highly significant increase of serum hs-CRP (P=0.01) in STEMI and NSTEMI subgroups when compared to UAP subgroup and highly significant increase of serum LDL-C (P=0.005) and serum hs-CRP(P=0.003) in UAP sub-group when compared to group II . There was also, a positive significant correlation between serum LDL-C and both serum CK-MB and serum hs-CRP in all subgroups.

Conclusion: Elevated serum LDL and hs-CRP may serve as markers of the severity of the disease which help evaluation and management of ACS patients.

KEYWORDS: Acute coronary syndrome-Lipid profile-Hs-CRP.

Introduction:

ACS remains the major cause of mortality and morbidity in the worldwide [1], which encompasses ST-segment elevation myocardial infarction (STEMI), Non–ST-segment elevation myocardial infarction (NSTEMI) and unstable angina pectoris (UAP) [2].Elevated demand can produce ACS in the presence of a high-grade fixed coronary obstruction, due to increased myocardial oxygen and nutrition requirements, such as those resulting from exertion, emotional stress, or physiologic stress e.g., from dehydration, blood loss, hypotension, infection, thyrotoxicosis, or surgery [3].

The diagnosis of acute myocardial infarction in this setting requires a finding of the typical rise of biochemical markers of myocardial necrosis in addition to at least one of the following: Ischemic symptoms, development of pathologic Q waves and ischemic ST-segment changes on electrocardiogram [4].

ACS is caused primarily by atherosclerosis. Most cases of ACS occur from disruption of a previously no severe lesion (an atherosclerotic lesion that was previously hemodynamically insignificant yet vulnerable to rupture). The vulnerable plaque is typified by a large lipid pool,

DOI: 10.12816/0002431

numerous inflammatory cells, and a thin, fibrous cap [5].

The major trigger for coronary thrombosis is considered to be plaque rupture caused by the dissolution of the fibrous cap, the dissolution itself being the result of the release of metalloproteinase (collagenases) from activated inflammatory cells. This event is followed by platelet activation and aggregation, activation of the coagulation pathway, and vasoconstriction. This process culminates in coronary intraluminal thrombosis and variable degrees of vascular occlusion. Distal embolization may occur. The severity and duration of coronary arterial obstruction, the volume of myocardium affected, the level of demand on the heart, and the ability of the rest of the heart to compensate are major determinants of a patient's clinical presentation and outcome [3].

The five major groups of lipoproteins, which are in order of size, largest to smallest, are chylomicrons, VLDL, IDL, LDL, and HDL. Low-density lipoprotein (LDL) is one of that enable transport of multiple different fat molecules, including cholesterol, within the water around cells and within the water-based blood stream. The higher levels of type-B LDL particles promote health problems and cardiovascular disease, they are often informally called the bad cholesterol particles, (as opposed to HDL particles, which are frequently referred to as good cholesterol or healthy cholesterol particles) [6].

Inflammation plays a key role in the initiation and promotion of atherosclerotic lesions and can trigger ACS by the induction of plaque instability. C-reactive protein (CRP) is an extensively studied inflammatory factor that is its prognostic value in cardiovascular diseases in recent years has become increasingly important [7]. Additionally, CRP is no longer merely considered a marker but also emerges as mediator of atherosclerosis [8]. Finally, it remains an unsolved issue whether CRP a potential therapeutic target, or if it just reflects an increased risk for unfavorable outcome as a by stander marker [8].

Therefore, the aim of this work was to evaluate the role of serum LDL-C and serum hs-CRP in patients with ACS.

Patients and Method:

The current study enrolled 45 ACS patients who had admitted in cardiac care unit (CCU) and intensive care units (ICU) in Al-Zahraa University Hospital, as group I. They were 12 (26.7 %) females and 33 (73.3%) males with age ranged between 30 - 80 years. Other 30 apparently healthy persons of matching age and sex were included in the study as healthy control (group II). They were 9 (30%) females and 21(70%) males with age ranged between 38 -87 years. Approval of the ethical committee of faculty of medicine, Al-Azhar University and informed consents were obtained from all subjects prior to the start of the study.

The patients and controls were divided into the following groups and subgroups:

I –Group I patients (45): were subdivided into three subgroups according to investigations done and the current guidelines:

a) STEMI as group (A) included 15 patients: 14 (93.3%) males and 1 (6.7%) females. Their age were ranged from 30-80 years. With of mean 54.73±12.81years.

b) NSTEMI as group (B) included 15 patients: 10 (66.7%) males and 5 (33.3%) females: Their age were ranged from 40-76 years. with mean of 58.2±9.60years.

c) UAP as group (C) included 15: patients 9 (60%) males and 6 (40%) females. Their age were ranged from 34-85 years with mean of 56.33±13.52 years.

II - Healthy control as group II: 9 (30%) females and 21(70%) males with age ranged between 38-87 years. with mean of 55.16±11.11years.

Comprehensive adult health history was taken and comprehensive physical examination was done.

All study participants were subjected to the following:

1- Standard 12-lead electrocardiography (ECG).
2- Trans-esophageal echocardiography.
3- Chest radiography.

4- Laboratory investigations: Serum total cholesterol, triglyceride, LDL-C, HDL-C, total creatine kinase (CK), CK-MB, cardiac troponin I (cTnI) and hs-CRP.

Three ml fasting (12-16 hours) venous blood sample was withdrawn from each subject and left to clot and centrifuged at 1000 xg for 15 minutes. HDL-C was immediately determined and the rest of the serum was stored at -20ºC for the remaining investigations.

The determination of serum total cholesterol, triglyceride was done on Hitachi auto analyzer 912 (Hitachi, Roche, Japan). HDL fraction was measured by Hitachi auto analyzer as described by Primatesta and Poulter [9]. LDL-C was calculated according to Friedwald formula [10].

Total CK was determined by kinetic UV method [11] (Hartman et al., 1998) supplied from Intermedical (Intermedical sri, Vallaricca, Italy). Serum CK isoenzyme MB (CK-MB) was measured by immunochemi-luminometric assay using kits supplied by Chemilumi ACS(Chemilumi ACS centaur, Bayer medical co Ltd, Tokyo ,Japan) as described by [12].

Cardiac troponin I is measured by sandwich immunoassay one step and was determined on Abbott AxSYM (Abbott Laboratories, 100 Abbott park road, Illinois, USA) [13].

Determination of hs-CRP was done by a solid phase immunosorbent assay (ELISA) and the kit was supplied by DRG International Inc (841 Mountain Avenue, Springfield, New Jersy, USA) [14].

EXCLUSION CRITERIA: Patients with chronic liver cell failure, chronic renal failure and diabetes mellitus were excluded.

Statistical Analysis:

The data were collected, revised, coded and entered to the statistical package for social science (SPSS) version 17 using Chi-square test and/or Fisher, independent t-test, Mann-Whitney test. Pearson and Spearman correlation coefficient

Results:

We found highly significantly increase of serum LDL-C (P=0.001), serum hs-CRP (P=0.001) and serum CK-MB (P =0.001) in group I when compared with group II. The serum cTn I increased in group I, as 30(66.70%) patients had positive results and the rest 15(33.30%) had negative result compared to group II (table 1).

We found highly significant increase in serum LDL-C and serum hs-CRP in STEMI and NSTEMI sub-groups (P=0.001) when compared with group II. The comparison of serum cTn I between STEMI and NSTEMI sub-groups showed that 15 (100%) patients had positive result (Table 2, 3) when compared with group II.

There was highly significant increase in serum LDL-C and serum hs-CRP in UAP sub-group (P =0.001) when compared with group II. There was non-significant difference of serum CK-MB in UAP sub-group when compared to group II (P > 0.05). All patients in UAP sub-group and group II had negative result of serum cTn I, (Table 4).

Comparing between the levels of serum LDL-C, serum hs-CRP and serum CK-MB in STEMI and NSTEMI sub-groups, there were non-significant differences, (P=0.095, 0.029 and 0.330 respectively). The comparison of serum cTn I between STEMI and NSTEMI sub-groups, showed that all patients in STEMI and NSTEMI sub-groups, had positive serum cTn I result (Table 5 and, fig. 1).

There were highly significant increases in levels of serum LDL-C, serum hs-CRP in STEMI sub-group, (P=0.024, 0.003 and 0.001 respectively). The comparison of serum cTn I between STEMI sub-group showed that all patients of STEMI sub-group (100%) had positive result and all patients of UAP sub-group had negative results (Table 6 and fig. 1).

There was a significant increase in serum LDL-C, serum hs-CRP, and serum CK-MB in NSTEMI sub-group (P=0.046, 0.01, 0.001 respectively). There was a highly significant increase of serum cTn I in NSTEMI sub-group as all patients (100%) had positive with comparison to UAP sub-group as all patients had negative results, (Table 7 and fig. 1).

Table (1): Comparison of laboratory parameters between groups I and II.

Parameters	Group I	Group II	P	Sig.
	Mean ± SD	Mean ± SD		
Age (years)	56.42±11.90	55.16±11.11	> 0.05	NS
LDL-C(mg/dl)	122.58±26.11	59.11±12.99	0.001	HS
CRP(mg/dl)	16.49±3.39	4.28±1.26	0.001	HS
CK-MB (U/L)	172.71±36.98	16.00±3.50	0.001	HS
Troponin I: :n,%				
Positive	30 (66.70%)	0 (0 %)		
Negative	15 (33.30%)	30 (100 %)		

LDL: Low density lipoprotein; CRP:C reactive protein; CK-MB: Serum creatine kinase- MB fraction.

Table (2): Comparison of laboratory parameters between subgroup A versus group II.

Parameters	Subgroup A Mean ± SD	Group II Mean ± SD	p-value	Significant
LDL-C(mg/dl)	115.04±25.96	59.11±12.99	0.001	HS
CRP(mg/dl)	19.55±4.38	4.28±1.26	0.001	HS
CK-MB (U/L)	269.44±65.66	16.00±3.50	0.001	HS
Troponin I:n,%				
Positive	15 (100 %)	0 (0 %)		
Negative	0 (0 %)	30 (100%)		

Table (3): Comparison of laboratory parameters between subgroups B versus group II.

Parameters	Subgroup B Mean ± SD	Group II Mean ± SD	p-value	Significant
LDL-C(mg/dl)	142.23±41.72	59.11±12.99	0.001	HS
CRP(mg/dl)	17.08±4.02	4.28±1.26	0.001	HS
CK-MB (U/L)	213.27±51.74	16.00±3.50	0.001	HS
Troponin I:n,%				
Positive	15(100 %)	0 (0 %)		
Negative	0(0 %)	30 (100.0%)		

Table (4): Comparison of laboratory parameters between subgroup C versus group II.

Parameters	Subgroup C Mean ± SD	Group II Mean ± SD	p-value	Significant
LDL-C(mg/dl)	85.14 ± 15.95	59.11 ±12.99	0.005	HS
CRP(mg/dl)	12.37 ± 4.25	4.28 ±1.26	0.001	HS
CK-MB (U/L)	18.71 ± 2.87	16.00 ± 3.50	0.144	NS
Troponin I :n,%				
positive	0 (0 %)	0 (0 %)		
negative	15 (100%)	30 (100%)		

Table (5): Comparison of laboratory parameters between subgroup A versus group B.

Parameters	Subgroup A Mean ± SD	Subgroup B Mean ± SD	p-value	Significant
LDL-C(mg/dl)	115.04±25.96	142.23±41.72	0.095	N S
CRP(mg/dl)	19.55±4.38	17.08±4.02	0.029	N S
CK-MB (U/L)	269.44±65.66	213.27±51.74	0.330	N S
Troponin I:n,% **positive** **negative**	 15 (100 %) 0 (0 %)	 15(100 %) 0 (0 %)		

Table (6): Comparison of laboratory parameters between subgroup A versus subgroup C.

Parameters	Subgroup A Mean ± SD	Subgroup C Mean ± SD	p-value	Significant
LDL-C(mg/dl)	115.04±25.96	85.14±15.95	0.024	HS
CRP(mg/dl)	19.55±4.38	12.37±4.25	0.003	HS
CK-MB (U/L)	269.44±65.66	18.71±2.87	0.001	HS
Troponin I: n,% positive negative	 15 (100 %) 0 (0 %)	 0 (0%) 15 (100%)		

Table (7): Comparison of laboratory parameters between subgroups B versus subgroup C.

Parameters	Subgroup B Mean ± SD	Subgroup C Mean ± SD	p-value	Significant
LDL-C(mg/dl)	142.23 ± 41.72	85.14 ± 15.95	0.046	S
CRP(mg/dl)	17.08 ± 4.02	12.37 ± 4.35	0.010	HS
CK-MB (U/L)	213.27±51.74	18.71 ± 2.87	0.001	HS
Troponin I:n,% positive negative	 15)100 %) 0 (0 %)	 0 (0%) 15 (100%)		

Table (8): Correlation between serum LDL-C versus serum CK-MB and serum hs-CRP in all subgroups.

Parameters	LDL-C Subgroup A			LDL-C Subgroup B			LDL-C Subgroup C		
	R	p-value	Sig	r	p-value	Sig	r	p-value	Sig
CK-MB (U/L)	0.643	0.010	S	0.847	0.001	HS	0.573	0.032	S
CRP(mg/dl)	0.956	0.001	HS	0.933	0.001	HS	0.968	0.001	HS

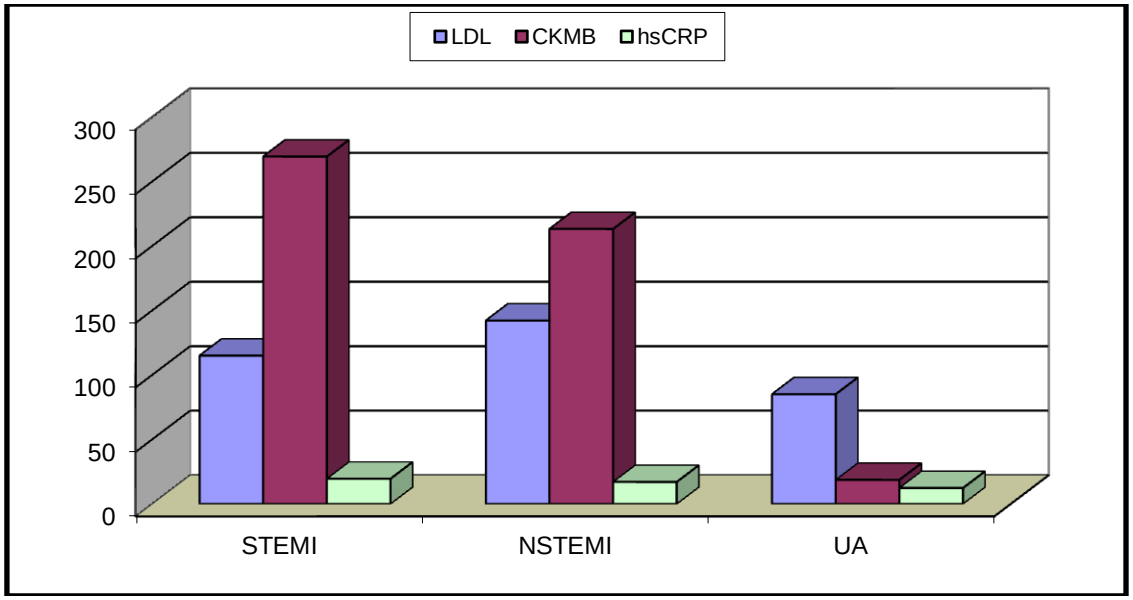

Figure (1): Comparison of serum LDL, serum CK-MB and serum hs-CRP in subgroups A, B and C.

Discussion

ACS is triggered by inflammatory response and plaque degradation [15], and is caused primarily by atherosclerosis [4]. Increased LDL-C level showed a significant positive correlation with the severity of ACS and that observation suggests that increased levels of LDL-C relate to plaque instability in coronary atherosclerotic lesions [16]. Other studies have reported that CRP elevation was associated with plaque rupture in ACS patients [17].

In the current study, we found a highly significant increase in serum LDL-C in ACS patients when compared to healthy control, and also highly significant increase of serum LDL-C in STEMI, NSTEMI and UAP patients when compared to healthy control. Krintus and his colleagues demonstrate a significant increase in serum LDL in ACS patients than healthy control [18]. In our study, the analysis of serum LDL-C among ACS patients showed that there was no significant difference between STEMI and NSTEMI patients and highly significant increase in both STEMI and NSTEMI in comparison to UAP patients. These results were in agreement with Ehara and his colleagues; who demonstrate a significant increase in serum LDL in AMI patients group when compared to UAP group [19].

In the current study, there was a highly significant increase serum level of hs-CRP in ACS patients in comparison to healthy control group. These results agreed with the result obtained by Krintus and his colleagues who found that; the concentration of CRP in ACS patients was 4-fold higher than healthy controls [18]. In our study, we found that highly significant increase of serum level of hs-CRP in STLMI patients, NSTEMI patients and UAP patients when comparing each sub-group to healthy control. Hence, the assessment of the diagnostic accuracy confirmed a very good ability of CRP to discriminate between cases and controls [18]. Also, there was non-significant difference of serum hs-CRP in STEMI when compared to NSTEMI patients. The level of serum hs-CRP showed highly significant difference in STEMI and NSTEMI when compared each subgroup to UAP patients. These observations were consistent with results of other researchers showing higher CRP concentrations in patients with myocardial infarction than stable or unstable coronary artery disease [20]. These results were also in agreement with Krintus and his colleague, who demonstrated that highest CRP levels were observed in STEMI and NSTEMI patients than in UA patients [18].

CRP levels are higher in patients with STEMI than those with NSTEMI with further and significant decrease of CRP in patients with UAP when compared to STEMI and NSTEMI [21], [22]. Therefore, the observed variation in CRP concentrations among the types of ACS might be at least partially attributed to the differences in the area of the infracted myocardium [23]. This can be explained by CRP which has been found in

atherosclerotic lesions and binds to LDL then taken up by macrophages without the need for modification of it [24] and promote inflammation by disrupt thromboregulation via suppresses prostacyclin synthase expression while potentially augmenting thromboxane A2 bioactivity which present in atherosclerotic lesions then elicits platelet aggregation and smooth muscle contraction that are prone to plaque rupture and thrombosis and development of ACS [14], [25].

Conclusion: serum LDL and serum hs-CRP elevated levels may serve as markers of the severity of the disease which help in evaluation and management of ACS patients. So the more severe lesions were associated with high level of serum LDL and serum hs-CRP.

Recommendations: In all cases with ACS, serum LDL and serum hs-CRP must be measured. Treatment of high level of serum LDL must be introduced early as soon as possible and continue as a maintenance treatment in all cases of ACS and heart disease with type II diabetes mellitus.

References:

1. **Rogers VL, Go AS, Lloyd-Jones DM, Adams RJ, Berry J D, Brown T M, and Carnethon M R (2011):** Heart disease and stroke update: a report from the American Heart Association Circulation,123: e18–209.
2. **Wiviott SD and Braunwald E (2004):** Unstable angina and non-ST-segment elevation myocardial infarction: Part I. Initial evaluation and management, and hospital care. Am Fam Physician, 70:525–32.
3. **Damman P, Holmvang L, Tijssen JG (2012):** Usefulness of the Admission Electrocardiogram to Predict Long-Term Outcomes after Non-ST-Elevation Acute Coronary Syndrome (from the FRISC II, ICTUS, and RITA-3 [FIR] Trials). *Am J Cardiol*., 109(1):6-12.
4. **O'Connor RE, Bossaert L and Arntz HR (2010):** acute coronary syndromes:International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Circulation*, 122: S422–65.
5. **Chughtai H, Ratner D and Pozo M (2011):** Prehospital delay and its impact on time to treatment in ST-elevation myocardial infarction, Am J Emerg Med. Med.,29(4):396-400.
6. **John D, Michael D, Ronald B (2008):** Lipoprotein Management in Patients With Cardiometabolic Risk, J Am Coll Cardiol.,51:1512-1524
7. **Swiatkiewicz, M. Kozinski, P. and Magielski P (2012):**"Usefulness of C-reactive protein as a marker of early post-infarct left ventricular systolic dysfunction," Inflammation Research, 61(7): 725–734.
8. **Bisoendial RJ, Boekholdt SM, Vergeer M (2010):** "C-reactive protein is a mediator of cardiovascular disease," European Heart Journal, 31, (17): 2087–2095.
9. **Primatesta P and Poulter NR. (2000):** Lipid concentrations and the use of lipid lowering drugs: evidence from a national cross sectional survey. BMJ , **321**: 1322 - 1325.
10. **Friedwald WT, Levy RI, Frederickson DS (1972):** Estimation of the concentration of low density lipoprotein cholesterol in plasma without use of the preparative ultracentrifuge. Clin Chem., 18: 499.
11. **Hartmann F, Kampmann M, Frey N, Muller-Bardorff M, Katus HA(1998):** Biochemical markers in the diagnosis of coronary artery disease. Eur Heart J., 19: N2-7.
12. **Piran U, Kohen DW, Uretsky L.S, Barlaw EH, Stastny M (1987):** Immunochemilunimometeric assay of ck MB with a monoclonal antibody to the MB isoenzyme, Clin. Chemi., 33:1517.
13. **Eggers KM, Oldgren J, Nordenskjöld A, Lindahl B (2004):** Diagnostic value of serial measurement of cardiac markers in patients with chest pain: limited value of adding myoglobin to troponin I for exclusion of myocardial infarction. Am Heart J., 148(4):574-81.
14. **Grad E, Pachino RM, Fitzgerald GA, Danenberg HD (2012):** Role of thromboxane receptor in C-reactive protein-induced thrombosis," Arteriosclerosis, Thrombosis and Vascular Biology, 32(10): 2468–2474.
15. **Liebetrau C, Gaede L, Szardien S, Rixe J, Doerr O, Willmer M, Weber M, Rolf A, Möllmann H, Elsässer A, Hamm C. and Nef H., (2013):** High Sensitivity CRP Predicts Long-Term Mortality in Patients with Atrial Fibrillation and Evident Acute Coronary Syndrome. International Journal of Clinical Medicine, 4:137-144.
16. **Zhang Y, Wei J, Wang F, Chen M. and Zhang M (2012):**Elevated Levels of Oxidized Low-Density Lipoprotein Correlate Positively with C-Reactive Protein in Patients with Acute Coronary Syndrome, Cell Biochemistry and Biophysics,62(2): 365-372.
17. **Joon YH, Ho MJ, Ha YC, Hee SC, Hwan SH, Suk JK, Goo ML, Ho KP, Doo SS, Sik NY, Ju HY, Hun HK, Han JK, Ahn Y, Gwan J, Chun JP and Chaee Kang J (2011):** Relation Between High-Sensitivity C-Reactive Protein and Coronary Plaque Components in Patients With Acute Coronary Syndrome: Virtual

Histology-Intravascular Ultrasound Analysis ,41.8.440

18. **Krintus M, Kozinski M, Stefanska A, Sawicki M, Obonska K, Fabiszak T, Kubica J and Sypniewska G (2012):** Value of C-Reactive Protein as a Risk Factor for Acute Coronary Syndrome: A Comparison with Apolipoprotein Concentrations and Lipid Profile Mediators of Inflammation, 2012: 1-10.
19. **Ehara S, Ueda M and Naruko T(2001):** Elevated levels of oxidized low density lipoprotein show a positive relationship with the severity of acute coronary syndromes. *Circulation, 103*: 1955–1960.
20. **Niccoli G, Biasucci LM and Biscione C (2008):** "Independent prognostic value of C-reactive protein and coronary artery disease extent in patients affected by unstable angina, *Atherosclerosis,* 196 (2): 779–785.
21. **Scirica BM, Morrow DA and Cannon CP (2007):** "Clinical application of C-reactive protein across the spectrum of acute coronary syndromes," *Clinical Chemistry*, 53(10): 1800–1807.
22. **Stefano DR, Di Bello V and Barsotti MC (2009):** "Inflammatory markers and cardiac function in acute coronary syndrome: Difference in ST-segment elevation myocardial infarction (STEMI) and in non-STEMI models," *Biomedicine and Pharmacotherapy*, 63(10):773–780.
23. **Habib SS, Kurdi MI, Al Aseri Z and Suriya MO(2011):** "CRP levels are higher in patients with ST elevation than non-ST elevation acute coronary syndrome," *Arquivos Brasileiros de Cardiologia*, 96(1):13–17.
24. **Kojuri J, Karimi A, Pourafshar N and Vosoughi AR (2010):** Association between Serum Levels Of Hs-CRP and LDL-C with Degree of Coronary Artery Stenosis in Patients with Stable Angina Pectoris. *Iranian Red Crescent Medical Journal* (IRCMJ), 12(4):396-405
25. **Roubín RS, Pardal BC, Roubín-Camiña F, Sanchez OR, Castro A (2013):** High-sensitivity C-reactive protein predicts adverse outcomes after non-ST-segment elevation acute coronary syndrome regardless of GRACE risk score, but not after ST-segment elevation myocardial infarction, Next Document Rev Port Cardiol., 32:117-22.