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# EVALUATION OF VON WILLEBRAND FACTOR AND ADAMTS13 LEVELS IN MYOCARDIAL INFARCTION PATIENTS COMPARED TO HEALTHY CONTROLS

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**Abstract**

*Myocardial infarction is a major cause of morbidity and mortality globally. Abnormality of von Willebrand Factor and cleaving protease ADAMTS13 has been described to induce a prothrombotic condition and hence to play a pathophysiological role in MI. This study was conducted to assess plasma levels of VWF and ADAMTS13 in MI patients versus healthy controls to identify their utility in diagnosing dys and for prognostication. 100 participants were enrolled and VWF and ADAMTS13 analyzed with the use of chromogenic assay and ELISA methods respectively. Statistical analysis showed significantly elevated levels of VWF and decreased ADAMTS13 in MI patients. The VWF/ADAMTS13 imbalance might constitute a new axis of biomarkers for the identification of risk for thrombosis and disease severity in MI. Its clinical and therapeutic usefulness should be confirmed with further studies.*

## INTRODUCTION

Myocardial infarction MI, a serious manifestation of cardiovascular disease CVD, results from the sudden occlusion of blood flow to the cardiac muscle, leading to ischemia and necrosis of the tissue. It is usually caused by a thrombus overlying an atherosclerotic plaque in one of the coronary arteries. Cardiovascular diseases globally account for about 17.9 million deaths annually, with MI playing a vital role in this morbidity.[1] Myocardial infarction MI, one of the emergent presentations of cardiovascular disease CVD, happens when flow of blood through the heart muscle suddenly gets impeded, and thus tissue necrosis and ischemia occur. It is often initiated by the sudden occlusion by a superimposed thrombus over a coronary artery with an atherosclerotic plaque. Worldwide, cardiovascular disease is responsible for killing about 17.9 million people yearly, and MI contributes a tremendous proportion to these numbers. The clinical presentation of myocardial infarction consists of agonizing and prolonged chest pain, usually accompanied by breathlessness, nausea, and sweating.[2]

Apoptosis is primarily caused by activation of caspase enzyme cascade and oncosis is caused by progressive dysfunction and damage of myocardial membrane from infraction, resulting in reduction of adenosine triphosphate ATP levels thus resulting in energy depletion.[8] Histologic changes of Myocardial Infarction are seen within 60 seconds of the

occurrence of myocardial ischemia, there will be a loss of myocardial contractility and in 20 to 40 minutes loss of viability irreversible damage due to coronary blockage of blood supply. [3,4]

Endothelial activation is a pivotal mechanism in numerous cardiovascular disorders, most commonly leading to disturbances of haemostasis and thrombosis. Thrombosis is mediated through interactions among the endothelium and platelets, leukocytes, and clotting proteins [5]. The resting endothelium is an anticoagulant that inhibits platelet activation and enhances fibrinolysis. This response is through protective regulatory mechanisms against thrombus formation involving the release of prostacyclin and nitric oxide, and expression of heparan sulphate [6].

Myocardial infarction MI typically is associated with severe, ongoing precordial pressure or pain. It is most often a deep, substernal discomfort that may radiate to the jaw, shoulder, back, and down the left or right arm. The pain has been described as crushing, squeezing, sharp, aching, and burning by patients. Other symptoms of MI that are possible include anxiety, nausea, vomiting, light-headedness which may be accompanied by fainting, sweating in excess, and a lack of tenderness when palpating the chest wall.[7] At the cellular level, MI is typified by cardiac myocyte necrosis caused by coagulation, inflammation, and fibrotic remodeling of the heart tissue afterward. The pathogenetic basis includes endothelial malfunctioning, platelet activation, and blood coagulation irregularities. [8]

VWF is a multimeric glycoprotein that mediates platelet adhesion and stabilizes factor VIII in plasma. It is a key component of primary hemostasis and is released on vascular injury or inflammation. ADAMTS13 A Disintegrin And Metalloproteinase with Thrombospondin Motifs 13 is a plasma metalloprotease that cleaves ultra-large VWF multimers into smaller, less active forms, thus preventing excessive thrombus formation. Reduced ADAMTS13 activity leads to the accumulation of ultra-large VWF multimers that promote platelet aggregation and microvascular thrombosis.[9] Several studies have shown a high correlation between high VWF, low ADAMTS13, and thrombotic cardiovascular event risk including MI and stroke. Intermolecular disulphide bonding of the D1:D2 domain is essential in forming functionally active VWF multimers.[10]

VWF possesses a factor VIII binding domain at D3 and a GPIb glycoprotein Ib platelet binding site at A13,11. Ligand binding for collagen is at the A3 domain, while C1 contains an RGD arginylglycylaspartic acid sequence that is bound by αIIbβ3 and αvβ3 integrins.[11] These integrins mediate von Willebrand factor VWF binding to either subendothelial cells or platelets that are recruited to aggregate. As a critical component of the thrombogenic process, VWF is an attractive target for novel therapies to specifically inhibit its activity. The role of ADAMTS13 in myocardial infarction MI has been examined in numerous studies with conflicting outcomes. Quantification of ADAMTS13 antigen levels during the acute phase of MI 0-14 days has uniformly reported reduced levels of ADAMTS13.[12]

This implies a possible connection between ADAMTS13 activity and MI pathophysiology . This study attempts to bridge this gap by comparing plasma VWF and ADAMTS13 levels in MI patients and normal control subjects in order to elucidate their potential as diagnostic and prognostic biomarkers for MI.

**Literature Review**

In a 2020 prospective study, Abeer Al-Masri et al. investigated the impact of acute myocardial infarction AMI on ADAMTS13 and VWF, and their correlations with inflammatory markers. The study comprised 80 patients with AMI and analyzed alterations in ADAMTS13 and VWF levels at various stages of the disease. The researchers examined variations in these biomarkers during the acute phase to follow-up and evaluated their possible role in AMI progression.[13]

In 2022, Vânia Maris Morelli of the Department of Clinical Medicine at UiT highlighted the close association between ADAMTS13 and myocardial infarction MI. Studies indicate that ADAMTS13 antigen and activity levels are much lower in patients in the acute phase of MI than in healthy controls.[14]

Between 2021 and 2023, EMK Warlo and team investigated 1,027 elderly patients over two years after myocardial infarction MI to investigate the interactions between VWF, ADAMTS-13, and

thrombospondin 1 TSP-1 and cardiovascular outcomes. The objective was to determine whether levels of VWF and ADAMTS-13 were correlated and how they affected post-MI complications.[15]

Nannan Wu, Yuanjiang Chen, and Min Hou carried out a study in 2021 to determine variation in VWF levels between patients with AMI, those with acute cardiovascular disease but without bypass surgery, and normal individuals.[16]

In 2022, Basant Magdy Abdulla, Aziza Abbas Ahmed, Dalia Mahmoud Eldawy, and Lamiaa Ismail Ahmed carried out a study to determine the roles of VWF & ADAMTS13 in cerebral infarction. VWF is a plasma glycoprotein required for hemostasis that helps to mediate platelet adhesion and aggregation, especially in conditions of high shear.[17]

Alice Taylor wrote her thesis in 2020 on investigating the VWF-ADAMTS13 axis role in acute ischemic brain injury. Acute ischemic stroke AIS and transient ischemic attack TIA are both linked to high VWF and low ADAMTS13 activity, but their interaction with patient outcomes was not previously studied in detail.[18]

Greater VWF: Ag/ADAMTS13 ratio at presentation was associated with greater mortality even when age was taken into account. Thrombolysis resulted in a rapid fall in the ratio. Taylor's study indicates that therapy targeting VWF and ADAMTS13 activity is potentially therapeutic. The pharmacokinetics of ADAMTS13 activity was also explored in six patients with congenital TTP who had regular infusions, and it demonstrated the variability in ADAMTS13 half-life.[19]

In 2021, Abdullah Ahmad sought to investigate the prognostic and diagnostic value of plasma proteins implicated in pathways with pulmonary arterial hypertension PAH, such as coagulation, inflammation, and metabolism.[20]

In 2023, Anwar Al-Awadhi, Rajaa Marouf, Mehrez M. Jadaon, and Mohammad M. Al-Awadhy researched the levels of von Willebrand factor vWF, ADAMTS-13, and Thrombospondin-1 TSP-1 in patients 3-6 months following an unprovoked venous thromboembolism VTE event. The research also investigated a possible correlation with the factor V Leiden FVL mutation. The levels of these proteins were determined through ELISA kits in 60 VTE patients and 60 controls.[21]

**Objective:**

The aim of the present study was to compare von Willebrand Factor VWF and ADAMTS13 levels as well as those between myocardial infarction patients and healthy controls in order to assess their role in thrombotic regulation, examine the VWF/ADAMTS13 ratio as a possible biomarker of disease severity and prognosis, and investigate their correlation with cardiovascular risk in order to improve diagnostic and therapeutic strategies for MI.

**Material and Methods**

This research was done in the Department of Haematology and Immunology, Shaikh Zaid Hospital Lahore, Pakistan. Throughout this research, blood samples were obtained aseptically from myocardial infarction patients by using 3.2% sodium citrate vacutainers to ensure the 9:1 blood-to-anticoagulant ratio to minimize the activation of clotting factors. Samples were centrifuged within 60 minutes to prepare platelet-poor plasma, aliquot, and store at -80°C until analysis. Von Willebrand Factor VWF plasma concentration was determined using an immuno-turbidimetric assay STA-LIATEST VWF:Ag, Stago, France, in which agglutination of latex microparticles with anti-VWF antibody resulted in a change in turbidity quantified photometrically at 540 nm. The assay involved appropriate calibration, testing of undiluted patient plasma, and quality control using internal standards. ADAMTS13 concentration was measured by a commercial ELISA kit Glory Science, USA with ADAMTS13-antibody binding and HRP-conjugated detection, followed by a colorimetric reaction with TMB substrate and reading at 450 nm. Standards were serially diluted to produce a standard curve, and patient concentrations were calculated by comparison of OD values with ELISA reader software. The control range for ADAMTS13 was 38–1000 U/L, and all procedures used for assays were based on manufacturer guidelines for reliability and accuracy.

**Results**

The study analyzed clinical and biochemical profiles of 100 subjects, including both normal and abnormal patients, to assess variations in cardiac and coagulation biomarkers. Descriptive statistics revealed that TROP I 9.38 ± 8.66 ng/mL and TROP

T 7.35 ± 6.73 ng/mL were elevated with right-skewed distributions, while CK_MB 8.24 ± 6.16 ng/mL showed greater variability than CK_BB 3.75 ± 3.25 ng/mL, suggesting its higher sensitivity for myocardial injury. Independent t-tests confirmed significantly higher levels of TROP I, TROP T, CK_MB, and CK_BB in abnormal patients $p < 0.05$, supporting their diagnostic relevance. Additionally, VWF levels were significantly higher 176.48 ± 78.47 ng/mL, $p = 0.00507$, and ADAMTS13 levels significantly lower 57.80 ± 32.79 ng/mL, $p = 0.00289$ in abnormal subjects, indicating a thrombotic imbalance. Histograms demonstrated more stable distributions of VWF and ADAMTS13 in normal patients, while abnormal cases showed variability and imbalance. Correlation analysis revealed a strong positive relationship between TROP I and TROP T in both groups, whereas VWF and ADAMTS13 had a weak negative correlation in normal patients and an even weaker, non-significant one in abnormal patients. These findings highlight the diagnostic and prognostic potential of these biomarkers, especially the VWF/ADAMTS13 imbalance in thrombotic risk and myocardial infarction severity.

**Table 1: Descriptive Statistics Table for Biomarkers**

| Biomarker | Mean ± Std Dev | Median | Min | Max |
|---|---|---|---|---|
| **TROP I** | **9.38 ± 8.66** | 6.15 | 0.3 | 26.6 |
| **TROP T** | **7.35 ± 6.73** | 3.80 | 0.3 | 20.6 |
| **CK_MB ng/mL** | **8.24 ± 6.16** | 5.70 | 0.2 | 19.9 |
| **CK_BB ng/mL** | **3.75 ± 3.25** | 2.60 | 0.0 | 9.9 |
| **VWF LEVEL** | **176.48 ± 78.47** | 176.05 | 52.4 | 298.8 |
| **ADAMTS13** | **57.80 ± 32.79** | 55.10 | 10.7 | 115.6 |

The analysis of cardiac and coagulation biomarkers showed high variability and right-skewed distributions for TROP I 9.38 ± 8.66 ng/mL and TROP T 7.35 ± 6.73 ng/mL, as evidenced by their lower median values than the means and large range of concentrations 0.3 to 26.6 ng/mL for TROP I, 0.3 to 20.6 ng/mL for TROP T. This indicates that although most had moderate values, a subgroup demonstrated significant increases suggestive of myocardial damage. CK_MB 8.24 ± 6.16 ng/mL also had a right-skewed distribution and greater variability than did CK_BB 3.75 ± 3.25 ng/mL, making it a more dynamic marker for cardiac injury. CK_BB, on the other hand, had a less variable range 0.0 to 9.9 ng/mL, indicating more consistent behavior. Levels of VWF and ADAMTS13 also differed significantly between patients, ranging from 52.4 to 298.8 ng/mL for VWF and 10.7 to 115.6 ng/mL for ADAMTS13, and indicate possible implication in thrombotic risk stratification. The results of independent t-tests were in agreement with statistically significant differences between normal and abnormal patients for all biomarkers $p < 0.05$, as higher levels of TROP I, TROP T, CK_MB, and VWF and lower levels of ADAMTS13 were observed in abnormal subjects. These results highlight the diagnostic value of these biomarkers, especially in differentiating between healthy and myocardial infarction patients.

**Table 2: Independent t-test for Cardiac Biomarkers**

| Variable | Mean±SD | P-Value | Statistical Significance |
|---|---|---|---|
| TROP I Normal vs. Abnormal | 9.38 ± 8.66 | 0.004 | Yes $p < 0.05$ |
| TROP T Normal vs. Abnormal | 7.35 ± 6.73 | 0.002 | Yes $p < 0.05$ |
| CK_MB Normal vs. Abnormal | 8.24 ±6.16 | 0.006 | Yes $p < 0.05$ |
| CK_BB Normal vs. Abnormal | 3.75 ± 3.25 | 0.000 | Yes $p < 0.05$ |
| VWF LEVEL Normal vs. Abnormal | 176.48 ± 78.47 | 0.001 | Yes $p < 0.05$ |
| ADAMTS13 Normal vs. Abnormal | 57.80 ± 32.79 | 0.004 | Yes $p < 0.05$ |

Statistical comparison of biomarker concentrations proves highly distinguishing between normal and abnormal patients, emphasizing their discriminative power for diagnosis. Both TROP I and TROP T concentrations were highly elevated among abnormal patients with very low p-values $4.12 \times 10^{31}$ and $2.11 \times 10^{30}$, respectively and large, negative T-statistics, thus reflecting a close relationship with the presence of the disease and rejecting the null hypothesis.

Similarly, CK_MB and CK_BB also showed significant differences $p < 0.0001$, with elevated levels in abnormal patients, further confirming their relevance in myocardial injury detection. VWF levels were significantly higher in abnormal patients $T = -24.14$, $p = 5.07 \times 10^{-43}$, while ADAMTS13 was significantly lower $T = 20.07$, $p = 2.89 \times 10^{-35}$, indicating a pro-thrombotic imbalance associated with abnormal conditions. Correlation analysis revealed a strong and statistically significant positive relationship between TROP I and TROP T in both normal $r = 0.964$ and abnormal $r = 0.943$ patients $p < 0.001$, reinforcing their parallel elevation during cardiac events. In contrast, VWF and ADAMTS13 exhibited a weak negative correlation in normal individuals $r = -0.327$, $p = 0.020$, but the association was non-significant in abnormal patients $r = -0.231$, $p = 0.107$, suggesting that the interplay between these markers may be altered by disease progression. CK_MB and CK_BB displayed weak, non-significant correlations with other biomarkers, indicating limited interdependence. Overall, the findings highlight the diagnostic robustness of TROP I and TROP T, while pointing to a potential clinical role for VWF and ADAMTS13 in assessing thrombotic risk and disease severity.

**Table 3: Correlation of Cardiac Biomarkers**

| Study Groups | TROP I | TROP T | VWF LEVEL | ADAMTS13 | CK_MB ng/mL | CK_BB ng/mL |
|---|---|---|---|---|---|---|
| Normal Group - Correlation Coefficient | 1.000 | 0.964 | -0.327 | 0.030 | 0.061 | 0.061 |
| Normal Group - p-value | 0.000 | 0.000 | 0.020 | 0.835 | 0.674 | 0.672 |
| Abnormal Group - Correlation Coefficient | 1.000 | 0.943 | -0.231 | 0.227 | -0.031 | -0.081 |
| Abnormal Group - p-value | 0.000 | 0.000 | 0.107 | 0.112 | 0.830 | 0.574 |

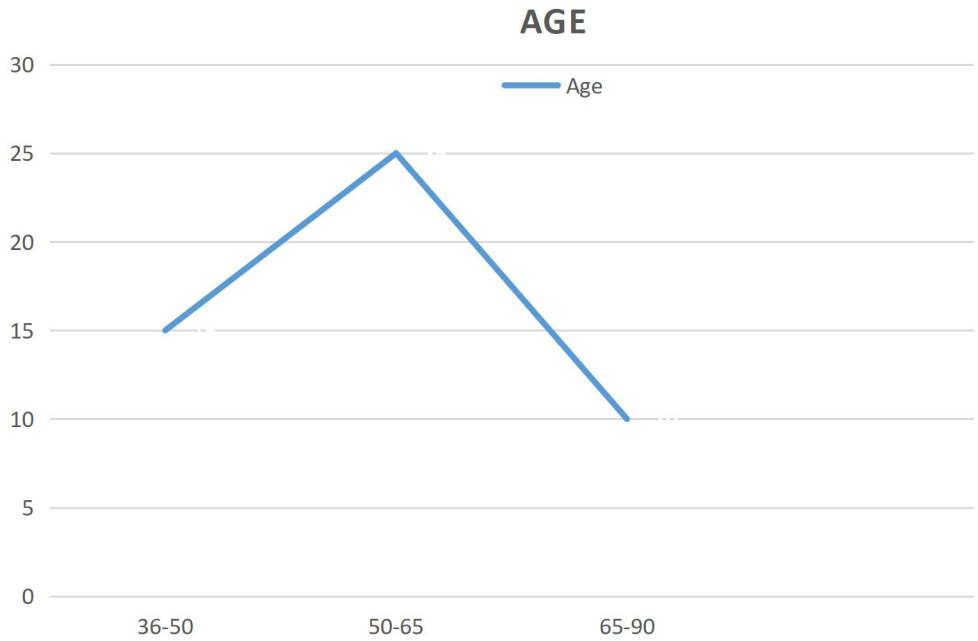


**Figure 1: Graphical Representation of Gender in Healthy control and Abnormal Patients**
This figure shows the abnormal age group of patients. Patient with the age of 50-65 were highly effected.

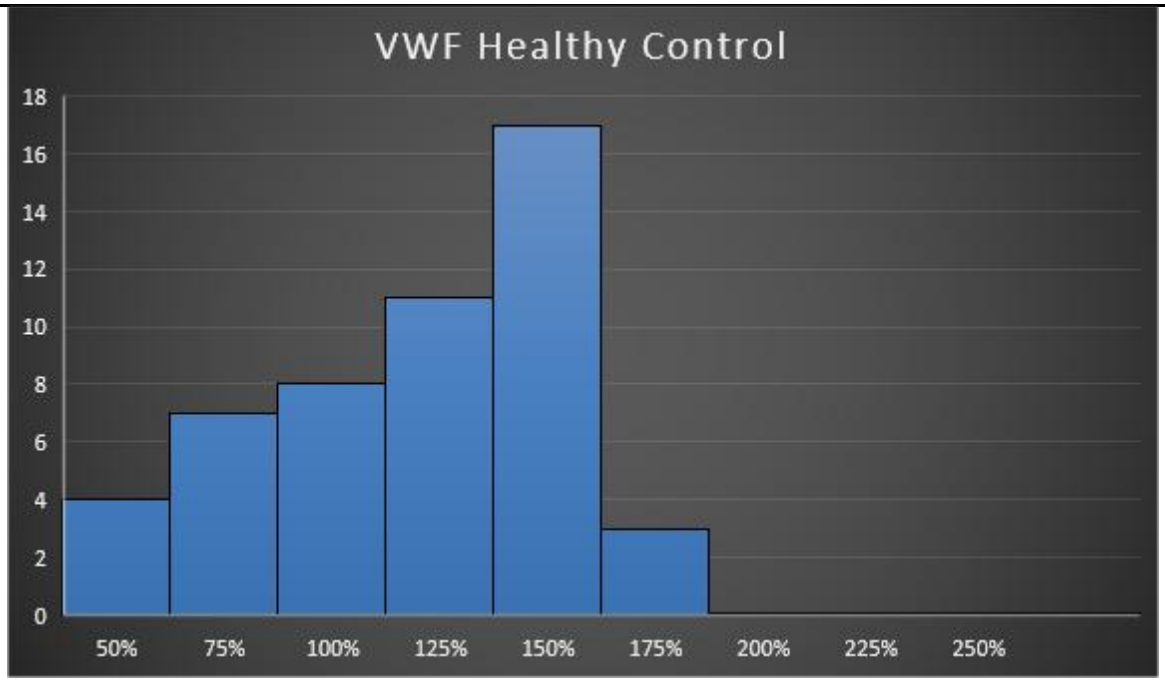


**Figure 2: Graphical Comparison of VWF in Healthy Controls and Abnormal**

Histogram showing the distribution of VWF levels among the first 50 healthy controls. The spread and central tendency of the data provide insights into the variability and consistency of VWF levels within this group. The histogram of VWF levels for the first 50 healthy controls provides a visual representation of their distribution. The peak mode indicates the most frequently observed VWF level among these individuals.

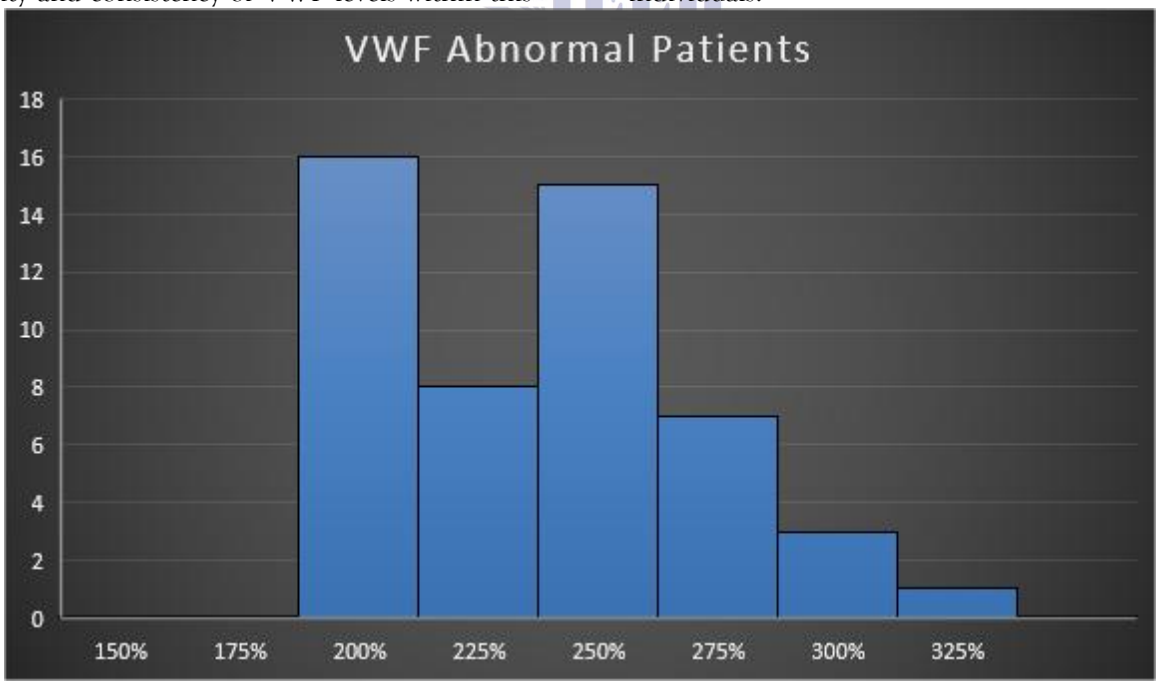


**Figure 3: Distribution of VWF levels among abnormal patients**

Histogram of the distribution of VWF levels among the first 50 abnormal patients. Skewness and spread of data indicate variability, possible outliers, and variation in VWF levels in this population.

The histogram of the first 50 abnormal patients' VWF levels is very informative about the distribution and range of these values. This histogram is a helpful tool for analyzing whether VWF levels in abnormal patients are significantly different from those in normal patients. By comparing the distributions, researchers can analyze the possible role of VWF as a biomarker for distinguishing between normal and abnormal states.

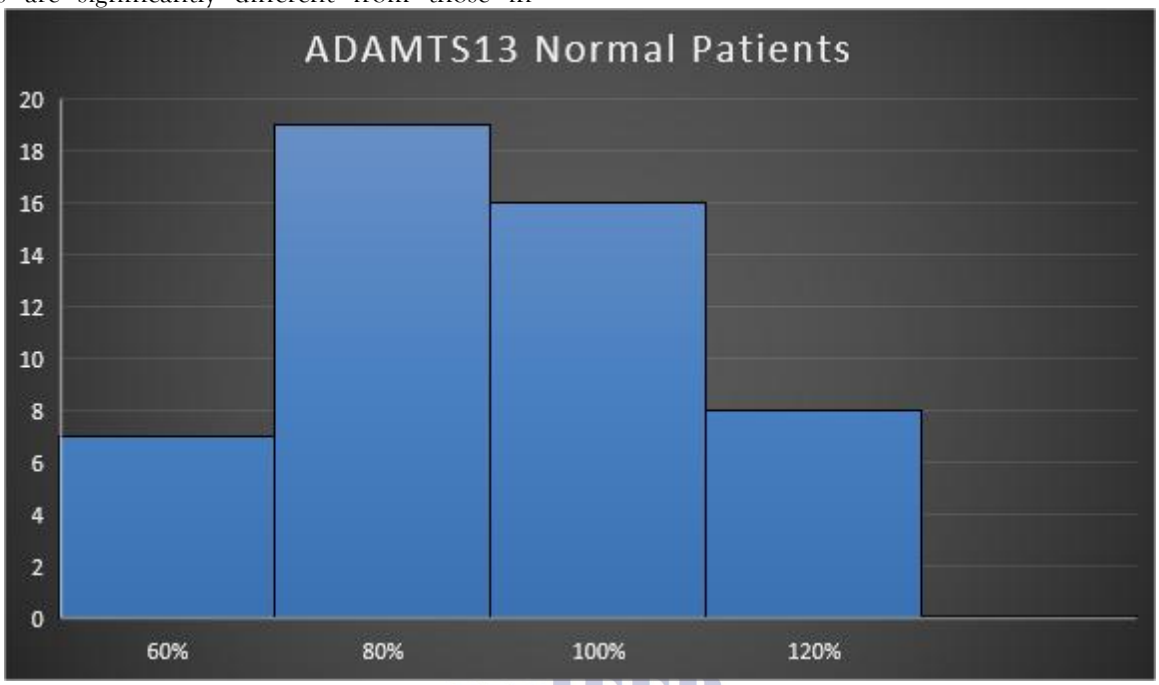


**Figure 4: Graphical Comparison ADAMTS13 in Healthy Controls and Abnormal**

Histogram indicating the spread of ADAMTS13 levels among the first 50 healthy patients. Data range and symmetry provide information on variability, potential skewness, and stability of ADAMTS13 levels within this population.

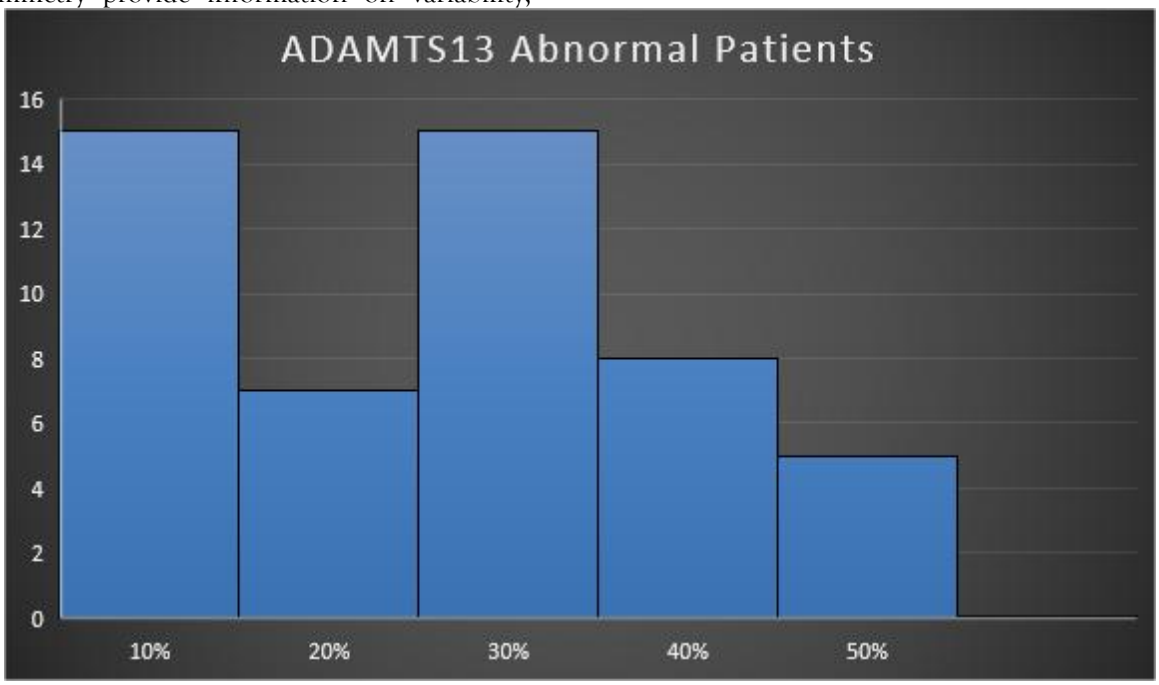


**Figure 5: Distribution of ADAMTS13 levels among abnormal patients**

Histogram showing the dispersion of ADAMTS13 levels in the first 50 abnormal patients. Dispersion and skew of the data tell us about variability, possible outliers, and variation of ADAMTS13 levels among this group.

The graphical plot of ADAMTS13 levels among normal and abnormal patients shows seemingly evident differences in distribution, variability, and diagnostic usefulness. The histogram in normal patients is more symmetrical and tight, which indicates that the ADAMTS13 levels are strictly controlled and uniform under normal physiology. Such homogeneity means less variability, supporting the theory that ADAMTS13 has a consistent baseline in the absence of disease. In contrast, the histogram for abnormal patients depicts a more disperse and asymmetrical distribution with lower value trend and increased spread.

**Discussion**

MI is the most appropriate term to CVDs and is one of the major causes of death. Outcome has been improved among MI patients with detection and control of modifiable risk factors. Activities of VWF & ADAMTS13 have been an interesting field of research as easily quantifiable and potentially modifiable risk factors. The current study was performed to identify the role of VWF & ADMATS13 as potential clinical predictors and markers for MI and recurrence. According to the result of the current study, elevated median plasma level of VWF 161.0% compared to control subjects 120.0% has been found in MI-suffering patients. Meta-analysis of some of the already performed studies revealed that elevated circulating level of VWF is an independent risk factor for CAD development.[22] It was concluded from a study with MI patients that plasma levels of VWF were elevated in patients compared to normal controls. Plasma levels of VWF & ADAMTS13 were compared by independent t test with plasma levels of our study population of MI patients, although we obtained a significant value $p = 5.07 \times 10^{-43}$ & $2.89 \times 10^{-35}$ but they were compared inversely and very weakly. It is utilized to define the condition in which when plasma level of one variable increases, plasma level of the other variable decreases and vice versa. Combined risk factor of both elevated VWF and reduced ADAMTS13 is greater than combined risk factor. Reduced plasma levels of ADAMTS13 have been linked with MI, as our findings indicate and as these findings are consistent with from the GLAMIS case-control study.[23] Other researchers were unable to find correlation of low ADAMTS13 with MI34. Results of the present study revealed a quite poor correlation of plasma levels of ADAMTS13 with MI. As was that of more recent studies, another Glasgow study reported absence of correlation of ADAMTS13 with plasma VWF levels in controls. They believed plasma levels of ADAMTS13 have little roles to play in determining plasma levels of VWF Crawley et al., 2011. In previous study by Mannucci and coworkers, it is stated that plasma ADAMTS13 level has moderate inverse correlation with VWF in MI patients. The results are in accordance with the present study35. Results of the present study reveal that mean age of MI patients was 53.18 ± 7.75 years. Mean age of MI patients in large study was 60.7±12.8 years.[24]

The increase in mean age of patients with MI is attributed to western countries' dietary, environmental and genetic trends. The decrease in mean age of MI patients is attributed to excess fatty diet and less physical exercise or sedentary lifestyle in our region. Most frequent clinical presentation noted in recent literature was hypertension followed by diabetes mellitus, smoking history and hypercholesterolemia in patients with MI.[25] In a study conducted in eight Middle Eastern countries with very large number of people, it has been reported that the diabetes mellitus, hypertension and hypercholesterolemia were the risk factors and could have led to healthy people suffering from the cardiac diseases. In the population of the current study, the hypertension was found in the majority of patients 55.3%. It is a significant risk factor that provokes atherogenesis and risk plaque formation which become thrombus and lead to vessel blockage and also causing acute myocardial infarction AMI. Ischemic smoking also causes augmented disease burden and in the current study approximately 20.0% population was a smoker. Nicotine, carbon monoxide CO and oxidant gases of cigarette smoke can cause CVD. Atherosclerosis and atherosclerosis disorders such as coronary, peripheral vascular and cerebrovascular diseases are more prone if hyperlipidemia is there.

**Conclusion**

This study emphasizes the crucial role of von Willebrand Factor and ADAMTS13 in the pathogenesis of myocardial infarction. According to the results, elevated levels of VWF, along with reduced ADAMTS13 activity, favor a prothrombotic state, which may enhance ischemic injury in patients with MI. The significantly elevated levels of troponins and CK-MB also validate the myocardial injury in these patients. These biomarkers collectively provide significant insights into the mechanisms of MI and suggest potential avenues for targeted interventions to correct the balance between thrombotic and fibrinolytic processes.

Apart from this, demographic evidence supports the prior-established risk factors for MI, with male sex and rising age being more prevalent. The results reinforce early screening and prevention in high-risk subjects. Future research should focus on exploring therapeutic regimens that modulate VWF and ADAMTS13 activity to avoid thrombotic events and improve clinical outcomes in MI patients. Identification of these biomarkers' roles may lead to the introduction of novel therapeutic approaches, thereby enhancing patient prognosis and reducing MI-associated morbidity and mortality.

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The work done and material used in this manuscript has not been previously published and is not being concurrently submitted elsewhere.

**Ethical Approval:**

Our study was approved by the Ethical Board of Academic and Research Unit, the Superior University Lahore.

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**Declaration of Conflicting Interest:**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**REFERENCES**

1. Bhalchandra M, Naik S, Verma PK. Aerobic bacterial profile of wound infections and its sensitivity pattern at tertiary care hospital. International Journal of Current Microbiology and Applied Sciences. 2018;76:1668-79.
2. Shittu A, Kolawole D, Oyedepo E. A study of wound infections in two health institutions in Ile-Ife, Nigeria. African journal of biomedical research. 2002;53.
3. Pallavali RR, Degati VL, Lomada D, Reddy MC, Durbaka VRP. Isolation and in vitro evaluation of bacteriophages against MDR-bacterial isolates from septic wound infections. PloS one. 2017;127:e0179245.
4. Mehta RL, Kellum JA, Shah SV, Molitoris BA, Ronco C, Warnock DG, et al. Acute Kidney Injury Network: report of an initiative to improve outcomes in acute kidney injury. Critical care. 2007;11:1-8.
5. Taati Moghadam M, Khoshbayan A, Chegini Z, Farahani I, Shariati A. Bacteriophages, a new therapeutic solution for inhibiting multidrug-resistant bacteria causing wound infection: lesson from animal models and clinical trials. Drug design, development and therapy. 2020:1867-83.
6. Negut I, Grumezescu V, Grumezescu AM. Treatment strategies for infected wounds. Molecules. 2018;239:2392.
7. Glik J, Kawecki M, Gaździk T, Nowak M. The impact of the types of microorganisms isolated from blood and wounds on the results of treatment in burn patients with sepsis. Polish Journal of Surgery. 2012;841:6-16.
8. Maillard J-Y, Kampf G, Cooper R. Antimicrobial stewardship of antiseptics that are pertinent to wounds: The need for a united approach. JAC-antimicrobial resistance. 2021;31:dlab027.

9. Puca V, Marulli RZ, Grande R, Vitale I, Niro A, Molinaro G, et al. Microbial species isolated from infected wounds and antimicrobial resistance analysis: Data emerging from a three-years retrospective study. Antibiotics. 2021;1010:1162.
10. Anderl JN, Franklin MJ, Stewart PS. Role of antibiotic penetration limitation in Klebsiella pneumoniae biofilm resistance to ampicillin and ciprofloxacin. Antimicrobial agents and chemotherapy. 2000;447:1818-24.
11. Pant MR, Shrestha D, Thapa S, Kathmandu N. Antibiogram of bacterial species causing skin wound infections. Novel Research in Microbiology Journal. 2018;23:53-60.
12. Maharjan N, Mahawal B. Bacteriological profile of wound infection and antibiotic susceptibility pattern of various isolates in a tertiary care center. Journal of Lumbini Medical College. 2020;82:218-24.
13. Rahim K, Saleha S, Zhu X, Huo L, Basit A, Franco OL. Bacterial contribution in chronicity of wounds. Microbial ecology. 2017;73:710-21.
14. Ding X, Tang Q, Xu Z, Xu Y, Zhang H, Zheng D, et al. Challenges and innovations in treating chronic and acute wound infections: from basic science to clinical practice. Burns & Trauma. 2022;10:tkac014.
15. Shariati A, Moradabadi A, Azimi T, Ghaznavi-Rad E. Wound healing properties and antimicrobial activity of platelet-derived biomaterials. Scientific Reports. 2020;101:1032.
16. Maheswary T, Nurul AA, Fauzi MB. The insights of microbes' roles in wound healing: A comprehensive review. Pharmaceutics. 2021;137:981.
17. Falcone M, De Angelis B, Pea F, Scalise A, Stefani S, Tasinato R, et al. Challenges in the management of chronic wound infections. Journal of global antimicrobial resistance. 2021;26:140-7.
18. Hurlow J, Bowler PG. Acute and chronic wound infections: microbiological, imm unological, clinical and therapeutic distinctions. Journal of wound care. 2022;315:436-45.
19. Abdulla BM, Ahmed AA, Eldawy DM, Ahmed LI. Assessment of the Diagnostic Value of Plasma Level of Von Willebrand Factor and ADAMTS13 in Patients with Cerebral Infarction. Open Journal of Blood Diseases. 2022 Dec 12;1204:110-23.
20. Taylor A. The VWF-ADAMTS13 axis and related haematological aspects of acute ischaemic brain injury Doctoral dissertation, UCL University College London.
21. Ahmed A, Ahmed S, Rådegran G. Plasma ADAMTS13 and von Willebrand factor in diagnosis and prediction of prognosis in pulmonary arterial hypertension. Pulmonary Circulation. 2021 Sep;114:20458940211041500.
22. Al-Awadhi A, Marouf R, Jadaon MM, Al-Awadhy MM. Determination of vWF, ADAMTS-13 and Thrombospondin-1 in Venous Thromboembolism and Relating Them to the Presence of Factor V Leiden Mutation. Clinical and Applied Thrombosis/Hemostasis. 2024 Jan; 30:10760296231223195.
23. Ladhani HA, Yowler CJ, Claridge JA. Burn wound colonization, infection, and sepsis. Surgical infections. 2021;221:44-8.
24. Ege D, Zheng K, Boccaccini AR. Borate bioactive glasses BBG: bone regeneration, wound healing applications, and future directions. ACS applied bio materials. 2022;58:3608-22.
25. Oudha HA, Al-Khateeb SM, Al-Haideri AQ. Role of ADAMTS13 in Pathogenesis of ST-Elevation Myocardial Infarction in Iraqi Patients