



Home > Archives > In Press

In Press

Quick Contents

Correctional abilities of regular muscle activity in relation to erythrocytes' microrheological features of rats with experimentally developed hypertension

Yury Vatnikov S. Yu Zavalishina E. V Kulikov I. F Vilkovskiy A. A Niklshov S. G Drukovsky E. A Krotova N. G Khomenets M.V Bolshakova
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Forecasting organizational silence according to moral behavior styles

Sina Yavarian Hassan Shams Esfand Abad Sadegh Taghi Lou
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Compliance with WHO safe surgery checklist in operating rooms: A case study in Iran Hospitals

Saeed Asefzadeh Sima Rafiei Mohammad Saeidi Masoomen Karimi
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Diagnostics of erythrocytes' microrheological features and early abnormalities of rats in the model of experimental hypertension development

Zavalishina Yuryevna et al. Yu. A Vatnikov E. V Kulikov S. A Yagnikov A. S Karamyan N. V Sturov V. M Byakhova M. V Kochneva A.V Petryaeva
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Genetic analysis of the complete genome of influenza A (H1N1) pdm09 during the first wave of the pandemic season in Indonesia

Hana Apsari Pawestri Ni K. Susilarini Kartika D. Puspa Hartanti D. Ikawati Kindi Adam Arie A. Nugraha Vivi Setiawaty
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Growth and minerals status in children with cerebral palsy in Shiraz, Iran during April 2012-April 2013

Firoozeh Fazlalizadeh Soroor Inaloo Naser Honar Fatemeh Razmjooii
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Accuracy and reliability of distal femoral rotation measurements using the transepicondylar axis in total knee arthroplasty: A cadaver study

Seyyed Morteza Kazemi Reza Minaei Mohammad Nabi Bahrani
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

The relationship between emotion dysregulation with psychoactive substance abuse in nurses working at hospitals of Kermanshah Iran 2016

Jahangir Karami Khoda Morad Momeni Peyman Hatamian
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Assesing sensitivity and specificity of rapid diagnostic test : the importance and challenges of influenza surveillance in Indonesia

Vivi Setiawaty Roselinda Roselinda Subangkit Subangkit Krisna Nur Andriana Pangesti
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Myocardial pathological changes in overtraining exercise

Made Kurnia Widiasuti Giri Ketut Indra Purnomo Muchsin Doewes Bambang Purwanto Ambar Mudigdo
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Phyllanthus niruri Linn increase infiltrating lymphocyte and apoptosis of rectosigmoid cancer patients. A phase II clinical trial

Ignatius Riwanto Parish Budiono Abdul Mughni Martahadinan Martahadinan Nugrahanta Dasa Putra Toar Deliezer Bram Mambu Mochamad Sayuti
[DOWNLOAD PDF](#) | [VIEW PDF](#) |

Impact estimation of long regular exercise on hemostasis and blood rheological features of patients with incipient hypertension

Kotova Vladimirovna Zavalishina S.Yu Makurina O.N Kiperman Ya.V Savchenko A.P Skoblikova T.V Skripleva E.V Zacepin V.I Skriplev A.V Andreeva V.Yu
[DOWNLOAD PDF](#) | [VIEW PDF](#) |



In Press

Submit An Article

Editorial Board

Scopus Citation



Official Journal of Indonesian Physical Therapy



GEJALA KANKER PAYUDARA

asiancancer.com

menggunakan
yang ditargetkan
untuk
membunuh sel-
sel kanker.

Ability to aggregation of basic regular blood elements of patients with hypertension and dyslipidemia receiving non-medication and simvastatin

Skoryatina Aleksandrovna Zavallshina S.Yu
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Effectiveness of teaching: jigsaw technique vs lecture for medical students' Physics course

Maryam Jafariyan Shahri Mohammad Matlabi Reza Esmaeili Mojtaba Jafariyan Shahri Kianmehr
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Risk factors of acute blood transfusion reactions in pediatric patients in Sanglah General Hospital, Bali-Indonesia

Ni Komang Tri Apriastini Ketut Ariawati
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Studying the relationship between spiritual intelligence of nurses and patients' satisfaction with nursing care

Fateneli Merati Fashi
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Effect of L-Arginine on glomerular endotheliosis improvement in preeclampsia

Sri Sulistyowati Nengah Budiarta Soetrisno Soetrisno
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Pediatric with differentiated thyroid cancer have higher recurrence rates than young adult patients: A retrospective cohort analysis for over 60 months

Yohana Azhar Dimiyati Achmad Kiki Lukman Dany Hilmanto
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Effect of continuous care model on self-care behaviors in heart failure patients: a randomized controlled trial (Continuous care model for self-care behaviors promotion)

Alireza Rahmani Yaser Moradi Khadijeh Aghakarimi
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Preparation and In-Vitro characterization of Self-Nano emulsifying system of C- Phenylcalix-[4]-Resorcinaryl Octacinnamate and C-Methylcalix-[4]-Resorcinaryl Octabenzoate as ultraviolet absorbers

Indrayani Agung Wiwiek Suwaldi Martodihardjo Soenardi . Jumina . I Gusti M Ngurah Budiana Mustofa .
[DOWNLOAD PDF](#) | [VIEW PDF](#)

A comparative study of individual and familial situation and history of diseases in female and male patients suffering from stroke

Shaysteh Salehi Shahrzad Tajmiri Ahmad Bahonar
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Effectiveness of life-skills training on the mental health of 2nd grade female High School students in Bam-Iran

Sedigheh Irannezhad
[DOWNLOAD PDF](#) | [VIEW PDF](#)

The anticancer activity of (e)-1-(4'-aminophenyl)-3-phenylprop-2-en-1-on against DMBA-induced mammary cancer in Sprague Dawley rat through the regulation of microRNA-21 expression

Ida Ayu Ika Wahyuniari I G K Nyoman Arijana Ni Putu Sriwidayani Ida Ayu Dewi Wiryanthini Hery Suwito Sitarina Widiyarini Muhammad Ghufur Mustofa . Sofia Mubarka
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Effect of oral saffron capsules on sleep quality in patients with diabetes at Zabol-Iran

Sadegh Dehghanmehr et al. Hossein Shadadi Ali Mansouri Azizollah Arbabisarjou
[DOWNLOAD PDF](#) | [VIEW PDF](#)

C-1562T polymorphism of matrix metalloproteinase-9 (MMP-9) gene associated with elevated level of plasma MMP-9 concentration in patient with acute myocardial infarction (AMI) in Denpasar-Bali

Ni Wayan Tianing Bagus Ari Pradnyana Dwi.P. Desak Made Wihandani
[DOWNLOAD PDF](#) | [VIEW PDF](#)

The effect of blended training (programmed and lecture-based training) on learning health status assessment course among nursing students

Hossein Jafarizadeh Alireza Rahmani Hossein Habibzadeh Sasan Amiri Ali Sadeghi Moghaddam Yaser Moradi
[DOWNLOAD PDF](#) | [VIEW PDF](#)

The serum Arginase-1 correlation to child-pugh scores in predicting the severity of cirrhosis

Siti Muchayat Purnamaningsih
[DOWNLOAD PDF](#) | [VIEW PDF](#)

Velocity of response to atypical and typical antipsychotics in the treatment of acute psychosis

Siroos Pakseresht Hamzeh Rostami Maryam Alavi
[DOWNLOAD PDF](#) | [VIEW PDF](#)



DiscoverSys
Whatever it takes...

Published by DiscoverSys

C-1562T polymorphism of *matrix metalloproteinase-9* (MMP-9) gene associated with elevated level of plasma MMP-9 concentration in patient with acute myocardial infarction (AMI) in Denpasar-Bali



CrossMark

Tianing Ni Wayan,¹ Bagus Ari Pradnyana Dwi P,² D.M Wihandani³

ABSTRACT

Background: Acute Myocardial Infarction (AMI) is an emergency medical condition which still has high mortality and morbidity. In recent decades, its prevalence has a tendency to increase, parallel with other chronic diseases. One of suspected contributing factor in AMI is the presence of C1562T polymorphism on MMP-9 gene which increases plasma MMP-9 concentration and destabilizes the plaque. However, this notion needs further confirmatory studies, as there are several contradictory reports regarding their association. This Study aimed to determine the relationship between C1562T polymorphism with the increase of MMP-9 concentration in AMI.

Method: A cross-sectional was conducted in Cardiovascular Centre of Sanglah General Hospital. The peripheral blood samples were obtained from subjects, and the DNA and blood plasma was isolated.

The polymorphism was detected using PCR and RFLP while MMP-9 concentration was determined by ELISA.

Results: The average concentration of plasma MMP-9 was found to be at 8.33 ng/mL which ranged from 0.74 ng/mL until 31.93ng/mL. The proportion of MMP-9 C1562T polymorphism was 20% of all subjects. The average concentration of MMP-9 was higher than *cut-off* standard which is 0.6 ng/mL. Analysis within the group revealed that CT-genotype had significantly higher average MMP-9 compared with CC phenotype (11.27 ng/mL vs. 7.65 ng/mL).

Conclusion: C1562T polymorphism appears to be significantly associated with AMI by increasing the concentration of MMP-9 in blood plasma.

Keywords: C1562T Polymorphism, MMP-9, Acute Myocardial Infarction

Cite This Article: Wayan, T.N., Dwi, B.A.P.P., Wihandani, D.M. 2017. C-1562T polymorphism of *matrix metalloproteinase-9* (MMP-9) gene associated with elevated level of plasma MMP-9 concentration in patient with acute myocardial infarction (AMI) in Denpasar-Bali. *Bali Medical Journal* 6(3): 601-605. DOI:10.15562/bmj.v6i3.754

^{1,3}Department of Biochemistry
Faculty of Medicine, Udayana
University, Bali-Indonesia

²Faculty of Medicine Udayana-
University/Sanglah Hospital, Bali
Indonesia

BACKGROUND

Acute Myocardial Infarction (AMI) is the major cause of cardiovascular disease related mortality and morbidity worldwide (WHO). Its principal pathophysiologic mechanism is coronary vascular stenosis or blockage due to atherosclerotic plaque rupture. Most of the risk factors of AMI are modifiable risk factors which include lifestyle, smoking, alcohol, and stress management. However, there are also non-modifiable risk factors which include genetic predisposition (BLA).¹

Left ventricular remodeling is a major determinant of prognosis in patients with acute AMI. This process was associated with post-AMI heart failure and life-threatening arrhythmias (Pfeffer, 1990).² Furthermore, the remodeling still occurs even in a patient who already treated with percutaneous coronary intervention (PCI). Thus, reperfusion is thought to be the inducing factor of ventricular remodeling (Bolognesa, 2002).³ In addition, Reactive Oxygen Species (ROS) produced in the areas of myocardial ischemia, especially after

reperfusion therapy. ROS could cause damage to cardiomyocyte membrane, leading to cell injury and apoptosis. ROS also induce signal transduction leading to increased expression of pro-inflammatory cytokines such as tumor necrosis factor- α (TNF- α), interleukin-1 and -6 (IL-1 and -6) in ischemic area and its surrounding. This cytokine stimulates apoptosis through the TNF- α receptor/caspase pathway which results in accumulation of intracellular Ca²⁺ and, eventually, necrosis of myocardial cells. Finally, ROS and proinflammatory cytokine activate matrix metalloproteinase that will hydrolyze extracellular matrix tissue that potentially results in left ventricular dilatation (Hori, 2008).⁴

Matrix metalloproteinase (MMPs) is a hydrolytic enzyme that degrades extracellular matrix and, hence, has a potential role in decreasing plaque stabilization (Peterson, 2000).⁵ In animal models, increased level of myocardial MMP has been associated with dilatation and dysfunction of the left ventricle (Apple and Mair, *et al.*).⁶

*Correspondence to:

Received: 2017-07-21

Accepted: 2017-08-28

Published: 2017-09-1

Table 1 Subject baseline characteristics

Variables	Value
Age	Mean: 50.04 (\pm 7.877) years
Plasma MMP-9 Concentration	Mean: 19.48 (\pm 7.18) ng/ml
Frequency of MMP-9 Polymorphism by Genotype	
CC	N: 58
CT	N: 13

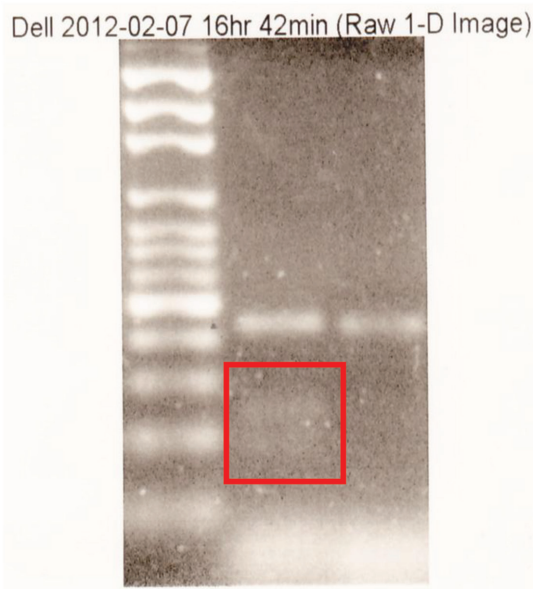


Figure 1 The result of amplicon restriction using *Pae I* (red square). The size of the fragments is 247 bp and 188 bp. Original fragment size is 435 bp.

Furthermore, genetic polymorphism in MMP-9 was known to increase the expression of MMP-9 both in vitro and in vivo studies (Blakenber, 2003 and Medley, 2003).^{7,8} MMP-9 is not only retained in the tissue level but also secreted into the blood plasma. Increase level of MMP-9 is known to be associated with left ventricular remodeling and leukocytosis (Spinale, 2000).⁹

Increased concentration of MMP-9 is related to the degree or severity of remodeling of the myocardium. However, constant plasma level of MMP-9 was related with stable ventricular systolic function. It appears that temporal increase rather than the absolute level of MMP-9 plays an important role in altering the degree of remodeling after MI (Kelly, 2007).¹⁰ In regards to plasma MMP-9, one of a predisposing genetic factor thought to be related to the risk of AMI is C1562T polymorphism on MMP-9 gene (Setianto, *et al.*, 2011).¹¹

In general, the relationship between polymorphisms with increased levels of MMP-9 and

left ventricular remodeling is still contradictory. The importance of knowledge about the measurement of the levels of MMP-9 and its relationship with the C1562T polymorphism of genes encoding MMP-9 would provide important development in a patient with AMI to avoid or inhibit the development of ventricular remodeling. Furthermore, as the study of MMP-9 polymorphism is never conducted in Indonesia, the polymorphism profile of Indonesian is still elusive and, hence, its relationship with AMI and left ventricular remodeling.

MATERIALS AND METHODS

A cross-sectional study evaluating the association between single-nucleotide polymorphisms (SNPs) in the promoter regions of MMP-9 was conducted in Sanglah General Hospital. 70 patients were enrolled and divided into acute myocardial infarction (AMI) with STEMI group, and Non-STEMI group with age ranged from 37 to 75 years old. Samples were collected consecutively from the patient of Sanglah Hospital Denpasar Bali Indonesia from June until December in 2011 which fulfilled the inclusion criteria. All samples that agree to participate were asked to fill the inform consent.

A whole blood sample was obtained for DNA isolation and plasma MMP-9 measurement. Total DNA was isolated using DNA isolation kit from Qiagen. MMP-9 gene was amplified using Polymerase Chain Reaction (PCR) procedure with a forward primer (5'-GCCTGGCACATAGTAGGCC-3') and reverse primer (5'-CTTCCTAGCCAGCCG GCATC-3'). The PCR kit was purchased from Qiagen. The PCR will yield 435 bp DNA products. To identify C1562T polymorphism of MMP-9 gene the products were treated with *PaeI* which resulted in 247 bp and 188 bp DNA fragments. Some of the PCR products were also sequenced to confirm the polymorphism.

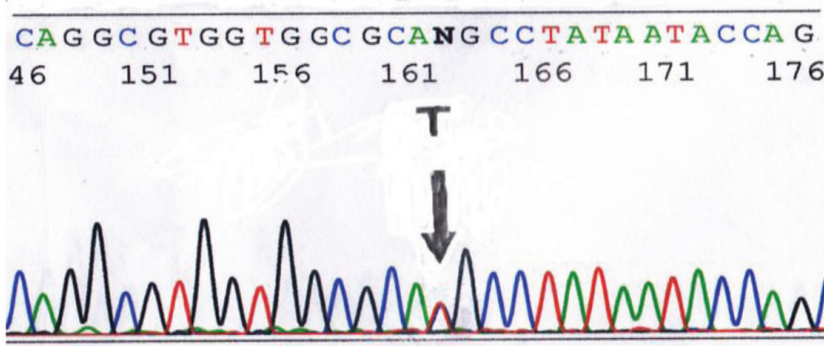
MMP-9 concentration evaluation was conducted using Enzyme Linked Immunosorbent Assay (ELISA) with reagents/ELISA kit from R & D Quantikine DPM900. The sample treatment, standard, and controls were formulated based on manufacturer protocol and measured at a wavelength 450.

Statistical analyses were conducted using SPSS version 17 for windows. Descriptive analysis was used initially to identify the proportion of MMP-9 gene polymorphism and the mean of MMP-9 concentration. Normality test was conducted using Kolmogorov-Smirnov test for numerical data. Independent sample T-test or Mann-Whitney test was used to compare the mean of MMP-9 between polymorphism groups.

Table 2 Mann-Whitney test results in comparing plasma MMP-9 concentration between CC and CT phenotype

MMP-9 Genotype	Mean Plasma MMP-9 Concentration
CC	18.2581 (± 7.057) ng/ml*
CT	24.9369 (± 4.97) ng/ml*

Note: The result is statistically significant ($p < 0.05$) based on Mann-Whitney test

**Figure 2** DNA sequencing heterozygote (CT) model

RESULTS

70 patients with AMI were enrolled in the course of this study. The age of the samples ranged from 37-80 years with most samples ages between 45-56 years (Table 1). The total DNA from all samples were successfully isolated and subsequently amplified using PCR. Then, the PCR products were treated by using *PaeI*, restriction enzyme to identify the C1562T MMP-9 polymorphism. The result of the restriction process is described in Figure 1.

As shown in Figure 1, *Pae I* cuts the original 435 bp amplicon into 247 bp and 188 bp fragments. The presence of such fragment indicates the presence of the C1562T polymorphism within the MMP-9 gene. However, because there is still original fragment within the same lane, the individual is considered as a heterozygote. Overall, we found 13 samples with CT-heterozygote (20%). We also sequenced several samples using BLAST method. The result of the heterozygote samples matched the result of restriction method.

The result of ELISA revealed that the plasma concentration of MMP-9 was varied but ranged from 0.74 ng/ml to 31.93 ng/ml. The average level was 19.48 (± 7.18) ng/ml. Analysis within each group revealed that the mean concentration of MMP-9 was 18.25 ng/ml for CC group and 24.93 for CT group (Table 2). Normality analysis showed that the data of plasma MMP-9 level was not normally distributed and, thus, the bivariate analysis was conducted using Mann-Whitney test instead of independent sample T-test. Bivariate analysis showed a significant association between plasma MMP-9 level with

MMP-9 gene C1562T polymorphism in which the heterozygote CT-genotype tend to has a higher level of MMP-9 compared to the homozygote one.

DISCUSSIONS

Cardiovascular disease remains the number one cause of death worldwide despite the development in its diagnosis and treatment.¹ The majority of CVD mortality and morbidity resulting from heart failure.² The main pathogenic mechanism for heart failure is ventricular remodeling in which MMP-9 plays a very important role.⁹ Development of heart failure and ventricular remodeling could significantly decrease cardiac function, decreasing the quality of life and increase the risk of cardiovascular-related death.

Because of the central role of MMP-9, the increasing level of MMP-9 could potentially elevate the risk and the degree of ventricular remodeling. In this study, we found a direct association of a C1562T polymorphism of MMP-9 with increased level of plasma MMP-9. MMP-9 plays an essential role in the pathophysiology of AMI. The basic pathophysiology of AMI is the rupture or erosion of atherosclerotic plaque. Plaque rupture is the result of collagen hydrolysis by a protease, especially MMP-9 (Newby, 2005).¹² The damaged heart muscle release intracellular protein such as troponin I (CTN-I) which is also a biomarker for AMI (Collinson, 2007; Setianto, *et al.* 2011).^{11,13}

According to our result, the plasma MMP-9 concentration was ranged from as low as 0.74 ng/ml to 31.93 ng/ml with an average of 8.33 ng/ml. This is considerably low compared with other studies.^{14,15} For example, Kelly *et al.* reported that the plasma MMP-9 concentration in AMI patients 12-hours after the onset was ranged from 15-376 ng/ml with median concentration at 70.0 ng/dl.¹⁴ Other study conducted by Squire *et al.* also report higher mean MMP-9 level at 49 \pm 11 ng/dl.¹⁵ The difference might result from the difference in subject criteria. Both studies used samples which already had ventricular remodeling. Meanwhile, this study used patients with AMI in which the remodeling status was still unknown. However, this study confirmed that the level of plasma MMP-9 was increased in a patient with AMI (normal plasma level: 140 pg/ml).¹⁶

Regarding the CT polymorphism, our study found that 20% of the subjects had the polymorphism. This finding is a little bit lower compared with Baiping *et al.* (1999) which found 26% proportion.¹⁷ However, Demack *et al.* found that the proportion was actually lower at 15.9%.¹⁸ The difference could result from the differences in the study population as well as the number of samples.

Nevertheless, because our study had fulfilled the minimum number of samples required, the validity of the proportion was not an issue.

Regarding the effect of the polymorphism toward the concentration of the plasma MMP-9, we found that there is a strong association between C-T polymorphism higher concentrations of plasma MMP-9. Our finding is consistent with several other studies despite the difference in the study population. The finding of Wu et.al and Opstad et.al were similar with us in whom they confirmed the relationship between the polymorphism with an elevated MMP-9 concentration in a patient with MI and ventricular remodeling.^{19,20} Opstad et.al also found that the risk was even more prominent in patients with metabolic syndrome.²⁰

The basic mechanism of increased risk of AMI and ventricular remodeling in a patient with C-T polymorphism can be explained as follow. Increased activity and level of MMP-9 increase the degradation rate of elastin, proteoglycans and collagen MEC which constitute the majority of subendothelial connective tissue.²¹ The loss of those components reduces the stability of the fibrous cap of the atheromatous plaque which will easily rupture by shearing stress from blood flow. After AMI had occurred, MMP-9 also had an important role in ventricular remodeling. The presence of increased amount of MMP-9 within myocardium increases the rate of fibrosis within the infarcted and penumbral area. Thus, lowering the contractile ability of ventricle and contribute to the development of heart failure. To conclude, C-T polymorphism act as negative predictor of the outcome of patient with AMI.²²

Nevertheless, this study had a limitation because the MMP-9 measurement was only conducted once and we did not use the peak level. Thus, the level of MMP-9 recorded in this study did not reflect the timely change of plasma MMP-9 in the plasma.

CONCLUSIONS

We demonstrate that the C-T polymorphism of MMP-9 gene is quite prevalent in Balinese population and it significantly associated with elevated level of plasma MMP-9 which could be related to adverse outcome in a patient with AMI.

ACKNOWLEDGMENT

Authors would like to acknowledge the contribution of Dr. Anwar Santosa for valuable critics and suggestions. This work was supported by a grant from RISBIN IPTEKDOK from the ministry of Research and Higher Education.

REFERENCES

- World Health Organization. Cardiovascular disease: Fact Sheet. 2016
- Pfeffer MA, Braunwald E. Ventricular remodeling after myocardial infarction. Experimental observations and clinical implications. *Circulation* 1990; 81: 1161 – 72.
- Bolognese L, Neskovic AN, Parodi G, et.al. Left ventricular remodeling after prAMIry coronary angioplasty: patterns of left ventricular dilatation and long-term prognostic implications. *Circulation* 2002; 106: 2351 – 57.
- Hori M and Nishida K. Oxidative stress and left ventricular remodeling after myocardial infarction. *Cardiovasc Res* 2008; 81(3): 457 – 64.
- Peterson JT, Li H, Dillon L, et.al. Evolution of matrix metalloproteinase and tissue inhibitor expression during heart failure progression in the infarcted rat. *Cardiovasc Res* 2000; 46: 307 – 15.
- Apple FS, Wu AHB, Mair J, et al. Future biomarkers for detection of ischemia and risk stratification in acute coronary syndrome. *Clinical Chemistry*. 2005;51; 810-24
- Blankenberg S, Rupprecht HJ, Poirier O, et.al. Plasma concentrations and genetic variant of matrix metalloproteinase-9 and prognosis of patients with cardiovascular disease. *Circulation* 2003; 107: 1579 – 85.
- Medley TL, Kingwell BA, Gatzka CD, et.al. Matrix metalloproteinase-3 genotype contributes to age-related aortic stiffening through modulation of gene and protein expression. *Circ Res* 2003; 92: 1254 – 61.
- Spinale FG, Coker ML, Heung LJ, et.al. A matrix metalloproteinase induction/activation system exists in human left ventricular myocardium and is up-regulated in heart failure. *Circulation* 2000; 102: 1944 – 9.
- Kelly D, Cockerill G, Leong L Ng, et.al. Plasma matrix metalloproteinase-9 and left ventricular remodeling after acute myocardial infarction in man: a prospective cohort study. *Eur Heart J* 2007; 28: 711 – 18.
- Setianto Budi Yuli, Indwiani astute, Bambang Irawan, Sofia Mubarika. Hubungan Matrikmetaloproteinase-9 (MMP-9) dengan Troponin-I (cTn-I) pada Infark Miokard dengan ST-Elevasi (STEMI) dan Sindroma Koronary Akut tanpa ST-Elevasi (NSTEMACS). *Journal Kardiologi Indonesia* volume 32 No 1 Januari-Maret 2011.
- Higo S, Uematsu M, Yamagishi M, et.al. Elevation of plasma matrix metalloproteinase-9 in the culprit coronary artery in patients with acute myocardial infarction clinical evidence from distal protection. *Circulation*.2005;69:1180-5
- Collinson PO, Gaze DC. Biomarkers of cardiovascular damage and dysfunction. An Overview, *Heart, Lung and Circulation*. 2007;16:S71-S82.
- Kelly D, Cockerill G, Ng L, Thompson M, Khan S, Samani NJ, and Squire IB. Plasma matrix metalloproteinase-9 and left ventricular remodelling after acute myocardial infarction in man: a prospective cohort study. *Eur Heart J*. 2007 Mar; 28(6): 711–718.
- Squire IB, Evans J, Ng L, Loftus IM, Thompson MM. Plasma MMP-9 and MMP-2 following acute myocardial infarction in man: correlation with echocardiographic and neurohumoral parameters of left ventricular dysfunction. *J of Cardiac Failure* 2004;10(4):328-333
- Thraillkill K, Cockrell G, Simpson P, Moreau C, Fowlkes J, Bunn RC. Physiological matrix metalloproteinase (MMP) concentrations: comparison of serum and plasma specimens. *Clin Chem Lab Med*. 2006; 44(4): 503–504.
- Baiping Zhang, Shu Ye, Stefan-Martin Herrmann, Per Eriksson, Moniek de Maat, Alun Evans, Dominique Arveller, Gerald Luc, Francois Cambien, Anders Hamsten, Hugh Watkins and Adriano M. Henney. Functional Polymorphism in the Regulatory Region of Gelatinase B Gene in Relation to Severity of Coronary atherosclerosis. *Circulation* 1999;99:1788-1794
- Demacq C, Vasconcellos VB, Marcaccini AM, Gerlach RF, Machado AA, Tanus-Santos JE. A genetic polymorphism of matrix metalloproteinase 9 (MMP-9) affects the changes in circulating MMP-9 levels induced by

- highly active antiretroviral therapy in HIV patients. *The Pharmacogenomics Journal* 2009; 9:265–273
19. Wu S, Hsu LA, Teng MS, Lin JF, Chang HH, Chang PY, Hu CF, Ko YL. Association of matrix metalloproteinase 9 genotypes and cardiovascular disease risk factors with serum matrix metalloproteinase 9 concentrations in Taiwanese individuals. *Clin Chem Lab Med.* 2010;48(4):543-9
 20. Opstad TB , Arnesen H, Pettersen AA, Seljeflot I. The MMP-9 -1562 C/T Polymorphism in the Presence of Metabolic Syndrome Increases the Risk of Clinical Events in Patients with Coronary Artery Disease. *PLOS ONE* 9(9): e106816.
 21. Peterson JT, Li H, Dillon L, et.al. Evolution of matrix metalloproteinase and tissue inhibitor expression during heart failure progression in the infarcted rat. *Cardiovasc Res* 2000; 46: 307 – 15.
 22. Weidemann F, Wacker C, Rauch A, et.al. Sequential changes of myocardial function during acute myocardial infarction, in the early and chronic phase after coronary intervention described by ultrasonic strain rate AMIging. *J Am Soc Echocardiogr* 2006; 19: 839 – 47.



This work is licensed under a Creative Commons Attribution