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Original Research Article

High sensitivity C-reactive protein level in cerebrovascular accident

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ABSTRACT

Background: Stroke is the second leading cause of death worldwide according to WHO. High sensitivity C-Reactive Protein (hs-CRP) is an acute phase reactant which is being studied extensively to delineate its role in development of stroke as well as in prognostication. This study was done to assess correlation of hs-CRP with risk factors of stroke and its association with types of stroke and prognosis.
Methods: A prospective case control study of 100 patients with acute stroke along with 100 controls was conducted with informed consent. At baseline, hs-CRP levels were measured and Modified Rankin Scale (MRS) was assessed. On day 90 the Modified Rankin Scale was assessed again. Patients were divided into groups based on hs-CRP levels and MRS and the results were analysed.
Results: Prevalence of stroke was more in men than women (p=0.0002). Statistically significant difference was found between mean hs-CRP levels in men (4.722±0.8982 mg/L) and women (4.133±0.9446 mg/L) (p=0.005) and between cases and controls (p=0.0003). There was no significant association with type of stroke (p=0.456). Mean total cholesterol levels between cases and controls showed statistically significant difference (p=0.0005). High MRS was significantly associated with high hs-CRP levels (p=0.003). Higher hs-CRP on day 1 correlated with higher MRS on day 90.
Conclusions: hs-CRP level is increased in stroke and shows significant association with severity of stroke and prognosis.

Keywords: Hemorrhagic stroke, High sensitivity C-reactive protein, Ischemic stroke, Modified rankin scale

INTRODUCTION

Stroke is a major cause of physical, mental and psychological morbidity. The overall disease burden of stroke is higher in the developing world and stroke also accounts for a greater relative proportion of total deaths in low- and middle-income countries. Two thirds of stroke deaths occur in less developed countries.[1] While the incidence of stroke is decreasing in high-income countries, the incidence is increasing in low-income countries.[2] The overall rate of stroke-related mortality is decreasing in high and low income countries, but the absolute number of people with stroke, stroke survivors, stroke-related deaths, and the global burden of stroke-related disability is high and increasing.[3]

Globally, the incidence of stroke due to ischemic causes is 68 percent, while the incidence of hemorrhagic stroke is 32 percent.[4] Men have higher incidence than women.[5,6] Stroke is more common in elderly though it can occur at any age.[6]

Stroke prevalence rate in India is about 1.54 per thousand and death rate about 0.6 per 1000. The DALYs (disability-adjusted life year) lost is about 597.6 per lac.[7] Total cases of stroke in India in the year 2004 were about 9.30 million with about 0.63 million deaths, and total DALYs lost in 2004 were about 6.36 million.[8]

High blood pressure, cigarette or beedi smoking, increased abdomen-to-hip ratio, diet and alcohol intake are significant risk factors for haemorrhagic stroke.[9] Physical inactivity, high levels of glucose, alcohol, stress related to psychosocial issues, cardiovascular causes, ratio of apolipoproteins B to A1 are more significant for ischemic stroke.[10]

A pivotal role in the pathogenesis of atherosclerosis and ischemic events is played by "inflammation".[11-13] Fibrinogen and hs-CRP which are markers of inflammation are predicted to be sensitive markers for degree of severity of stroke and the outcome.[14,15] hs-CRP is synthesised by hepatocytes as an acute phase reactant after tissue injury or infection.[16] hs-CRP expression is controlled by pro-inflammatory mediators such as IL-1, IL-6, TNF etc at the transcription level, among which IL-6 plays a very important role.[13]

Study done by Whiteley et al, on biomarkers for stroke showed that rising levels of hs-CRP, fibrinogen and IL-6 were associated with higher incidence of death due to vascular or non-vascular causes and increased risk of recurrent vascular events.[17] There is evidence of rising levels of hs-CRP for ischemic type of stroke which has been demonstrated in multiple studies but evidence for rising level in case of hemorrhagic type are very few.[18-20] The rise of hs-CRP also depends on the size of infarct.[13] A sustained inflammatory response is seen after an acute ischemic stroke with high levels of hs-CRP in 75% people.[21]

With this background, authors aim was to study the role of hs-CRP in stroke patients, both as a risk factor and prognostic factor using Modified Rankin Scale among suburban area of Indian population who are visiting the hospital.[22]

METHODS

The study was conducted on patients with first episode of ischemic/hemorrhagic stroke admitted in Medical wards and ICU of SRM Medical college hospital and Research Centre from 2016 to 2018. 100 patients and 100 normal healthy individuals participated in this case control study.

Inclusion criteria

Patients presenting with history of focal neurological deficit of acute onset in the form of hemiparesis, hemianesthesia or aphasia or having evidence of ischemic or hemorrhagic infarct in CT scan of the brain.

Exclusion criteria

- Patients with infectious pathology, arthritis, carcinoma, history of recent MI or acute coronary syndrome, hepatic failure.
- Patients presenting with focal neurological deficit after 72 hours
- Patients on drugs i.e. NSAIDS, statins, hormone replacement therapy.
- Recurrent stroke or TIA.
- Infiltrate on chest radiography.
- Patients who refuse consent.

Dyslipidemia was defined as total cholesterol >200 mg/ dl or known case of dyslipidemia with or without medications.

After obtaining informed consent, the patients and controls were subjected to detailed history, clinical examination and investigations as per the proforma. Neurological deficit was scored using the Modified Rankin Scale as given below. Modified Rankin Scale was assessed on day 1 of the admission. Sample for the hs-CRP was collected from patients within 72 hours of onset of the stroke. Hs-CRP level was estimated by SPINREACT KIT (CRP - ULTRASENSITIVITY LATEX TURBIDIMETRY) which helps in measuring the low levels of C-reactive protein. In this kit, hs-CRP levels below 3 mg/L were considered as normal. Patients were followed up after 90 days and reassessed for neurological deficit using the MRS to demonstrate the usefulness of hs-CRP for prognosis of stroke.

Statistical analysis

Data was processed and analysed by SPSS version 23.0 software. Categorical variables expressed as frequencies and percentages. The comparison of normally distributed continuous variables between the groupswas performed using Mann Whitney's test and Kruskal Wallis test was used for nonparametric data.

Nominal categorical data between the groups were compared using Chi-square test. Test results was deemed significant at 95% confidence intervals $p<0.05$.

RESULTS

Among 100 cases, 54 were Ischemic stroke and 46 were hemorrhagic stroke.

Age and gender distribution

The mean age among cases was 59.95±12.399 years and 58.02+13.043 years among controls as shown in Table 1.

Most cases were in the 41-60 and >60 years group, equally distributed. This was not statistically significant ($p = 0.457$) as seen in Table 2.

Table 1: Comparison of mean age of cases and controls.

Group	N	Mean	SD
Cases	100	59.95	12.399
Controls	100	58.02	13.043

Hemorrhagic stroke was more prevalent among those aged between 41 to 60 years (59.1%), while among those above 60 years of age ischemic stroke predominated (66%). This was statistically significant (p = 0.050) as shown below (Table 3). Among cases, there were 73 males and 27 females. There were 70 males and 30 females among controls. Males were significantly more than females in both groups (p value 0.0002).

Table 2: Age distribution among cases.

Age range	Case	Control	Total	p value (Pearson's Chi-square)
≥40 years	6	9	15	0.457
41-60 years	44	49	93	
>60 years	50	42	92	
Total	100	100	200	

Table 3: Type of stroke in different age groups.

Age range	Ischaemic	Haemorrhagic	Total	p value (Pearson's Chi-square)
≥40 years	3	3	6	0.050
41-60 years	18	26	44	
>60 years	33	17	50	
Total	54	46	100	

Table 4: Lipid profile in cases and controls.

Mean value Mg/dl	Cases N = 100	Controls N = 100	p value
Total cholesterol	169.15	144.52	0.005
LDL	113.95	101.62	0.015
VLDL	27.93	22.09	0.001
HDL	40.82	37.32	0.026
Triglycerides	132.04	110.43	0.026

Dyslipidemia in cases and controls

Total mean cholesterol level in cases was 169.15 mg/dl and 144.52 mg/dl in controls. This was statistically significant (p = 0.0005).

Mean LDL level among cases was 113.95 mg/dl and 101.62 mg/dl among controls and this was statistically significant (p = 0.015).

The difference in mean VLDL level between cases (27.93 mg/dl) and controls (22.09 mg/dl) was also statistically significant (p = 0.001). Differences in HDL levels and triglyceride levels also showed statistical significance as seen in Table 4.

hs-CRP levels

The difference between mean hs-CRP among cases (4.563 mg/ml) and among controls (0.825mg/ml) was significant (p = 0.0003) (Table 5). Mean hs-CRP level was significantly higher among men than women (p = 0.005) (Table 6).

Table 5: hs CRP in cases and controls.

Group	Frequency	Mean (mg/ml)	SD	p value
Cases	100	4.563	0.9434	0.0003
Controls	100	0.825	0.3883	

Table 6: Correlation of mean hs-CRP with gender.

Gender	Mean(mg/L)	SD	p value
Male	4.722	0.8982	0.005
Female	4.133	0.9446	

Mean hs-CRPwas4.381 mg/L in ischemic stroke and 4.226 mg/L in hemorrhagic stroke which was not statistically significant (p = 0.456) as shown in Table 7.

Table 7: Mean hs-CRP and stroke type.

Type of stroke	N	Mean(mg/L)	SD	p value
Ischaemic	54	4.381	1.0241	0.456
Haemorrhagic	46	4.226	1.0459	

Relationship between hs-CRP level and Modified Rankin Scale

hs-CRP values were grouped as high level >3 mg/L and low level <3 mg/L. 90 cases had high hs-CRP levels while 10 had low levels. Patients were also divided into two groups based on Modified Rankin Scale - MRS 0 to 2 (low) and MRS 3 to 6 (high).

Mean hs-CRP values on day 1 and day 90 of the different MRS are given below in Table 8 and Table 9, respectively. p value was statistically significant for both day 1 (p = 0.0004) and day 90 (p = 0.0003). Comparison of mean hs-CRP on day 1 and day 90 in each score of MRS as per the 2 tables shows that while on day 1 there were no patients with MRS 5 and 6, on day 90, 37 patients had progressed to MRS 5 and 9 patients had progressed to MRS 6. Higher hs-CRP correlated with higher MRS on day 90.

Table 8: Mean hs-CRP value and MRS on day 1.

MRS	1	2	3	4	5	6	p value
Frequency	2	35	59	4	0	0	0.0004
Mean hs-CRP	3.850	4.563	4.981	4.775	0	0	

Table 9: Mean hs-CRP value and MRS on day 90.

MRS	1	2	3	4	5	6	p value
Frequency	1	12	13	28	37	9	0.0003
Mean hs-CRP	4.6	3.4	4.2	4.589	4.965	4.9	

Table 10: hs-CRP values and MRS scores - Day 1.

Parameter	Group	MRS score on day 1		p value
		0 - 2	3 - 6	
	Low level <3	8	2	0.003
	High level >3	29	61	

Table 11: hs-CRP values and MRS scores - Day 90.

Parameter	Group	MRS score on day 90		p value
		0 - 2	3 - 6	
	Low level < 3	7	3	0.0002
	High level >3	6	84	

Table 12: MRS and type of stroke on day 1.

Diagnosis	Modified Rankin Scale		Total	p value
	0 - 2	3 - 6		
Ischaemic	18	36	54	0.411
Haemorrhagic	19	27	46	

Table 10 and 11 show that at baseline, patients with high hs-CRP scored high on MRS (p = 0.003) and this number increased by day 90 (p value = 0.0002). MRS of ischaemic stroke patients did not differ significantly from that of haemorrhagic stroke patients (p = 0.411) (Table 12). In both groups, more patients had high scores on day 1.

By day 90, disability had worsened in the majority of patients in both ischaemic and haemorrhagic strokes as seen in Table 13. This was statistically significant (p = 0.003).

Table 13: MRS and type of stroke on day 90.

Diagnosis	Modified Rankin Scale		Total	p value
	0 - 2	3 - 6		
Ischaemic	2	52	54	0.003
Haemorrhagic	11	35	46	

DISCUSSION

Stroke is the third leading cause of mortality in India according to CDC 2012 and a major cause of disability.[23] Recent studies have shown a correlation between increased hs-CRP levels and risk of stroke.[24,25] A prospective study was conducted on the same which included 100 cases of acute stroke of whom 54 were ischemic stroke and 46 were hemorrhagic type. A control group of 100 healthy patients were selected and subjected to the same procedure.

Distribution of age was between 30 to 80 years with the mean age among cases being 59.95±12.399 years which was lower than the study done by Aliakbar et al.[26] The mean age among the controls was 58.02±13.043 years. The maximum number of patients among cases were between 41 to 60 years although there was no statistical significance (p = 0.457). In the 41 - 60 years age group the prevalence of ischemic stroke was 40.9% (n = 18) and the prevalence of hemorrhagic stroke was 59.1% (n = 26). In the age group >60 years prevalence of ischemic type was 66% (n = 33) and prevalence of hemorrhagic type was 34% (n = 17) which was statistically significant (p = 0.05).

The sex distribution among men and women in cases and controls was statistically significant (p = 0.0002) with men showing higher prevalence in both groups which

was similar to other studies except for O' Malley et al, and Pikija et al, that showed female preponderance.[27,28] The mean hs-CRP level in men in cases was 4.722±0.8982 mg/L and in women it was 4.133±0.9446 mg/L which was again statistically significant (p = 0.005). This was similar to the study conducted by Yoshiyuki Wakugawa et al.[20] Estrogen is postulated to have a modulating effect over response to atherosclerosis and injury which may possibly account for this.[29]

There was no statistical significance between the two types of stroke (p = 0.456) in contrast to research done by Lal R et al.[30] Prevalence of ischemic stroke among men was higher than hemorrhagic type, 75.9% vs 69.6% while among women, the prevalence of hemorrhagic type was higher (30.4%) compared to ischemic type (24.1%). Fasting lipid profile was higher in cases compared to controls which was statistically significant. But when total cholesterol, TGL, HDL, LDL and VLDL in cases were compared to mean hs-CRP level in cases (p = 0.499, p = 0.591, p = 0.395, p = 0.582, p = 0.608) respectively, there was no statistical significance.

The mean hs-CRP level in cases was 4.563±0.9434 mg/L and 0.825±0.3883 mg/L in controls which was highly significant (p = 0.0003), similar to study conducted by Pinky Mishra et al.[31] The mean hs-CRP level in ischemic stroke was 4.381±1.0241 mg/L and 4.226±1.0459 mg/L in hemorrhagic type. This was not statistically significant (p = 0.456). This was similar to study done by Yoshiyuki Wakugawa et al, in the Hisayama study but different to the study done by Pinky Mishra et al, which showed higher hs-CRP in hemorrhagic stroke.[20,31]

Mean hs-CRP was 4.417 mg/L in the age group <40 years, 4.409 mg/L in the age group between 41 - 60 years and 4.716 mg/L in the age group>60 years which was not statistically significant (p = 0.271).

The mean hs-CRP on day 1 with MRS 1 was 3.850±0.3536 mg/L, MRS 2 was 3.874±0.8093 mg/L, MRS 3 was 4.981±0.7619 mg/L, MRS 4 was 4.775±1.1442mg/L which was significant statistically (p=0.0004) while there were no patients in MRS 5 and MRS 6 (Table 8). The mean hs-CRP on day 90 of MRS 1 was 4.6 mg/L, MRS 2 was 3.4±1.06 mg/L, MRS 3 was 4.2±0.672 mg/L, MRS 4 was 4.589±0.612 mg/L, MRS 5 was 4.965+0.876 mg/L, MRS 6 was 4.9+0.970 mg/L. All were significant statistically (p = 0.0003) (Table 9). Increasing disability was seen as evidenced by progression of Modified Rankin Scale on day 90 as compared to day 1 correlating with higher hs-CRP. Ritesh Lal et al, showed a similar prognostic correlation using the Scandinavian stroke scale.[30] The Bergen stroke study, also reported a similar result which showed that higher hs-CRP level was associated with higher stroke severity and mortality.[32] Study by Elkind et al, concluded that hs-CRP which is an acute phase reactant is elevated in more severe stroke and can be associated with mortality.[33]

High level vs low level hs-CRP values

hs-CRP values were considered in 2 groups

Low level group <3 mg/L and high level group >3 mg/L. Most of the patients belonged to high level group (n=90) which is similar to the study conducted by Jaydip Ray Chaudhuri et al.[34] Muir et al, had elevated CRP levels (>10 mg/L) in 96 out of 228 patients admitted with acute stroke.[35] In contrast, in a study from Netherlands only 22% of stroke patients had high CRP levels.[36]

Patients were also divided into two groups based on Modified Rankin Scale - MRS 0 to 2 in one group and MRS 3 to 6 in the second group. On day 1, 61 patients with high level hs-CRP were found to be in group of MRS 3 - 6 while only 2 with high MRS score had low level hs-CRP which was significant statistically (p = 0.003). On day 90, the number of patients with high hs-CRP levels scoring high on MRS had gone up to 84 which was also highly significant (p = 0.0002).

On day 1 there were no patients in MRS 5 and 6. But on follow up on day 90, the MRS scores were found to have progressed, 37 patients out of 100 had a Scale of 5 and 9 patients out of 100 had a score of 6. Mean hs-CRP level of each score has been described previously. Higher hs-CRP on day 1 correlated with the higher MRS on day 90.

There was statistical significance (p = 0.003) between hs-CRP and MRS on day 1and also between hs-CRP and MRS day 90, which shows correlation between hs-CRP level and MRS which is similar to results of study conducted by Song et al.[16] Only one value of hs-CRP was obtained. Also, patients were not followed beyond 3 months, therefore long term outcome was not assessed was the major limitations of the study.

CONCLUSION

In this case-control study of 100 patients with stroke and 100 healthy controls, men had higher prevalence of stroke (p = 0.0002). Most of the patients were more than 40 years of age. The mean hs-CRP level was higher in stroke patients compared to healthy individuals which was highly significant (p = 0.0003). There was significant difference in hs-CRP levels between men and women.

There was no significant difference in mean hs-CRP level between ischemic and hemorrhagic type of stroke. The correlation of mean of hs-CRP levels with Modified Rankin Scale on day 1 was significant statistically (p = 0.0004); so also the MRS score on day 90 (p=0.0003). Higher hs-CRP levels correlated with the higher Modified Rankin Scale on day 90.

hs-CRP could be therefore be used as a tool to identify those stroke patients who may need more intensive rehabilitation to reduce disability.

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REFERENCES

1. Warlow C, Sudlow C, Dennis M, Wardlaw J, Sandercock P. Stroke. Lancet 2003;362(9391): 1211-24.
2. Johnston SC, Mendis C, Mathers CD. Global variation in stroke burden and mortality: estimates from monitoring, surveillance, and modelling. Lancet Neurol. 2009 Apr;8(4):345-54.
3. Feigin VL, Forouzanfar MH, Krishnamurti R, Mensah GA, Connor M, Bennett DA. Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. Lancet. 2014;383(9913):245-54.
4. Feigin VL, Lawes CM, Bennett DA, Barker-Collo SL, Parag V. Worldwide stroke incidence and early case fatality reported in 56 population-based studies: a systematic review. Lancet Neurol. 2009 Apr;8(4):355-69.
5. Appelros P, Stegmayr B, Terént A. Sex differences in stroke epidemiology: a systematic review. Stroke. 2009 Apr 1;40(4):1082-90.
6. Holroyd-Leduc JM, Kapral MK, Austin PC, Tu JV. Sex differences and similarities in the management and outcome of stroke patients. Stroke. 2000 Aug;31(8):1833-7.
7. Indian Council for Medical Research. Stroke. In: Assessment of the burden of non-communicable diseases: Final project report. New Delhi: ICMR. 2004:18-22.
8. Govt. of India (2011), National Health Profile 2011, Ministry of Health andFamily Welfare, New Delhi. Available at: https://www.cbhidghs.nic.in/index1.php?lang=1&level=2&sublinkid=82&lid=77.
9. Neaton JD, Wentworth DN, Cutler J, Stamler J, Kuller L. Risk factors for death from different types of stroke. Annals Epidemiol. 1993 Sep 1;3(5):493-9.
10. Jia L, Hao F, Wang W, Qu Y. Circulating miR-145 is associated with plasma high-sensitivity C-reactive protein in acute ischemic stroke patients. Cell Biochem Func. 2015 Jul;33(5):314-9.
11. Muir KW, Tyrrell P, Sattar N, Warburton E. Inflammation and ischaemic stroke. Curr Opin Neurol. 2007 Jun;20(3):334-42.
12. Packard RR, Libby P. Inflammation in Atherosclerosis: From Vascular Biology to Biomarker Discovery and Risk Prediction. Clin Chem. 2008 Jan;54(1):24-38.
13. Youn CS, Choi SP, Kim SH, Oh SH, Jeong WJ, Kim HJ, et al. Serum highly selective C-reactive protein concentration is associated with the volume of ischemic tissue in acute ischemic stroke. Am J Emerg Med. 2012 Jan;30(1):124-8.
14. Vibo R, Kõrv J, Roose M, Kampus P, Muda P, Zilmer K, et al. Acute phase proteins and oxidised low density lipoprotein in association with ischemic stroke subtype, severity and outcome. Free Radic Res. 2007 Mar;41(3):282-7.
15. Tu WJ, Dong X, Zhao SJ, Yang DG, Chen H. Prognostic value of plasma Neuroendocrine biomarkers in patients with Acute Ischemic stroke. J Neuroendocrinol. 2013 Sep;25(9):771-8.
16. Song IU, Kim JS, Kim YI, Lee KS, Jeong DS, Chung SW. Relationship between High-Sensitivity C-ReactiveProtein and Clinical Functional Outcome after Acute Ischemic Stroke in a Korean Population. Cerebrovasc Dis. 2009;28:545-50.
17. Whiteley W, Jackson C, Lewis C, Lowe G, Rumley A, Sandercock P, et al. The association of circulating inflammatory markers with recurrent vascular events after stroke: a prospective cohort study. Stroke. 2011 Jan;42(1):10-6.
18. Wang Q, Ding H, Tang JR, Zhang L, Zu YJ, Yan JT, et al. C-reactive protein polymorphisms and genetic susceptibility to ischemic stroke and hemorrhagic stroke in the Chinese Han population. Acta Pharmacol Sin. 2009;30(3):291-8.
19. Wakugawa Y, Kiyohara Y, Tanizaki Y, Kubo M, Ninomiya T, Hata J, et al. C-reactive protein and risk of first-ever ischemic and hemorrhagic stroke in a general Japanese population: the Hisayama Study. Stroke. 2006 Jan 1;37(1):27-32.
20. Andersson J, Johansson L, Ladenvall P, Wiklund PG, Stegmayr B, Jern C, et al. C-reactive protein is a determinant of first-ever stroke: prospective nested case-referent study. Cerebrovas Dis. 2009;27(6):544-51.
21. Di Napoli M, Papa F, Bocola V. Prognostic influence of increased C-reactive protein and fibrinogen levels in ischemic stroke. Stroke. 2001 Jan;32(1):133-8.
22. Specifications Manual for Joint Commission National Quality Measures (v2016B). Available at: https://manual.jointcommission.org/releases/TJC2016B/DataElem0569.html. Accessed 1 July 2017.
23. WHO Statistical Resources, India. Available at https://www.cdc.gov/globalhealth/countries/india/default.htm
24. Patgiri D, Pathak MS, Sharma P, Kutum T, Mattack N. Serum hsCRP: A Novel Marker for Prediction of Cerebrovascular Accidents (Stroke). J Clin Diagn Res. 2014 Dec;8(12) CC08-CC11.
25. Elkind MS, Coates K, Tai W, Paik MC, Boden-Albala B, Sacco RL. Levels of acute phase proteins remain stable after ischemic stroke. BMC Neurol. 2006 Dec 1;6(1):37.
26. Taheraghdam A, Aminnejad S, Pashapour A, Rikhtegar R, Ghabili K. Is there a correlation between hs-CRP levels and functional outcome of Ischemic Stroke?. Pak J Medical Sci. 2013 Jan;29(1):166-9.

27. O'Malley T, Langhorne P, Elton R, Stewart C. Platelet size in stroke patients. Stroke. 1995;26(6):995-9.
28. Pikija S, Cvetko D, Hajduk M, TrkuljaV . Higher mean platelet volume determined shortly after the symptom onset in acute ischemic stroke patients is associated with a larger infarct volume on CT brain scan sand with worse clinical outcome. Clini Neurol Neurosurg. 2009;111(7):568-73.
29. Mendelsohn ME, Karas RH. The protective effects of estrogen on the cardiovascular system. N Engl J Med. 1999;340(23):1801-11.
30. Lal R, Gupta A, Virmani SK, kumar Tyagi V, Sharma S. High sensitivity C-reactive protein as a prognostic marker in ischaemic and haemorrhagic stroke. Inter J Adv Med. 2016 Apr;3(2):372.
31. Mishra PT, Chandra R, Saxena SK, Verma S, Jain R, Bhuyan A. High sensitivity c-reactive protein (hsCRP) level in cerebrovascular accident (Stroke). Age (yrs). 2010;58:52-76.
32. Idicula TT, Brogger J, Naess H, Waje-Andreassen U, Thomassen L. Admission C–reactive protein after acute ischemic stroke is associated with stroke severity and mortality: The 'Bergen stroke study'. BMC neurology. 2009 Dec;9(1):18.
33. Elkind MS, Luna JM, Moon YP, Liu KM, Spitalnik SL, Paik MC, et al. High-sensitivity C-reactive protein predicts mortality but not stroke: the Northern Manhattan Study. Neurol. 2009 Oct20; 73(16):1300-7.
34. Chaudhuri JR, Mridula KR, Umamahesh M, Swathi A, Balaraju B, Bandaru VSS. High sensitivity C-reactive protein levels in Acute Ischemic Stroke and subtypes: A study from a tertiary care center. Iran J Neurol. 2013;12(3):92-7.
35. Muir KW, Weir CJ, Alwan W, Squire IB, Lees KR. C-reactive protein and outcome after ischemic stroke. Stroke. 1999;30(5):981-5.
36. den Hertog HM, van Rossum JA, van der Worp HB, van Gemert HM, de Jonge R, Koudstaal PJ, et al. C-reactive protein in the very early phase of acute ischemic stroke: association with poor outcome and death. J Neurol. 2009; Dec 256(12):2003-8.

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