ORIGINAL ARTICLE

GMJ.2025;14:e3866
www.salviapub.com

Received 2025-04-08
Revised 2025-05-02
Accepted 2025-05-26

Investigating the Relationship between Demographic, Radiological and Clinical Factors and In-Hospital Mortality of Non-Traumatic Subarachnoid Hemorrhage Before and After COVID-19 Pandemic

Seyed Hossein Aghamiri [1], Negar Mohamadi Khorasani [2], Hossein Farshadmoghadam [3]✉

[1] Department of Neurology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2] School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3] Department of Pediatrics, Children Growth Research Centre, Research Institute for Prevention of Non-Communicable Disease, Qazvin University of Medical Science, Qazvin, Iran

Abstract

Background: Subarachnoid hemorrhage (SAH) is a life-threatening neurological condition that accounts for approximately 5% of all strokes. This study aimed to evaluate the demographic, clinical, and radiological factors associated with in-hospital mortality in patients with non-traumatic SAH and to assess potential differences before and after the COVID-19 pandemic. **Materials and Methods:** This retrospective analytical study was conducted on 177 patients with non-traumatic SAH admitted to Imam Hossein Hospital, Tehran, from November 2021 to December 2022. Diagnosis was confirmed by a neurologist using clinical presentation, imaging, and cerebrospinal fluid analysis. Patients were grouped based on discharge status (deceased vs. survived), and also classified into early- and late- pandemic subgroups based on their admission date. Comparative analyses and binary logistic regression were performed to identify predictors of in-hospital mortality. **Results:** Among 177 patients (mean age: 54.75 years), 36 (20.3%) died during hospitalization. Blood pressure, blood sugar, and level of consciousness at admission were significantly associated with mortality ($P < 0.05$), as were disease severity (Hunt and Hess grade) and angiography status ($P < 0.001$). No significant associations were found for age, sex, hospitalization duration, creatinine, platelets, hypertension, diabetes, or aneurysm characteristics ($P > 0.05$). Logistic regression identified lower Glasgow Coma Scale (GCS) scores ($P < 0.001$) and higher systolic blood pressure ($P = 0.004$) as independent predictors of mortality. Mortality was higher in the late-pandemic group (23.9% vs. 16.0%), though not statistically significant ($P = 0.18$). **Conclusion:** Lower GCS scores and elevated systolic blood pressure at admission were independent predictors of in-hospital mortality in patients with non-traumatic SAH. The COVID-19 pandemic period was associated with reduced use of angiography and a trend toward increased mortality, underscoring the importance of maintaining access to timely care during public health crises. **[GMJ.2025;14:e3866] DOI:10.31661/gmj.v14i.3866**

Keywords: Subarachnoid Hemorrhage; Mortality; Covid-19, Risk Factors; Glasgow Coma Scale; Aneurysm; Angiography

GMJ

✉ **Correspondence to:**
Hossein Farshadmoghadam, Department of Pediatrics, Children Growth Research Centre, Research Institute for Prevention of Non-Communicable Disease, Qazvin University of Medical Science, Qazvin, Iran.
Telephone Number: 0283 323 9164
Email Address: Hosseinfarshadmoghadam@gmail.com

Introduction

Subarachnoid hemorrhage (SAH) contributes to about 5% of all stroke events [1, 2]. This hemorrhage occurs within the subarachnoid space, located between the arachnoid membrane and pia mater, and often leads to cerebral edema and neurological complications [3–5]. While traumatic brain injuries are a common cause, roughly 85% of SAH cases are non-traumatic in origin [1, 2], with ruptured cerebral aneurysms accounting for over 80% of spontaneous events [6, 7].

Elevated hemodynamic stress plays a critical role in aneurysm formation. Persistent hypertension can induce inflammation in vessel walls, promoting structural weakening and potential rupture [8]. Inflammatory cytokines have also been implicated in this process [9, 10]. Besides hereditary predisposition, lifestyle factors such as hypertension, smoking, and alcohol use significantly contribute to aneurysm development [11, 12].

Timely identification and management are crucial for favorable outcomes in non-traumatic SAH [13, 14]. Diagnosis is more straightforward in patients presenting with severe symptoms [13, 15], but subtle cases may be missed, resulting in delayed intervention and worse prognosis. Misdiagnosis rates during initial assessments have been reported at approximately 12% [16, 17].

Importantly, the COVID-19 pandemic has profoundly affected healthcare systems worldwide, with potential consequences for the diagnosis, treatment, and outcomes of acute cerebrovascular events, including SAH. Limited hospital resources, delayed presentations, and hyperinflammatory responses associated with SARS-CoV-2 infection may influence both the clinical course and prognosis of patients. Recent studies have highlighted altered patterns of aneurysm rupture and increased mortality during the pandemic period [18, 19]. Therefore, assessing the impact of the COVID-19 era on SAH characteristics and mortality is essential for future preparedness and optimization of care. Given these challenges, the present retrospective study aimed to evaluate the relationship between demographic, radiological, and clinical factors and hospital mortality in patients with non-traumatic SAH, with a specific focus on differences before and after the COVID-19 pandemic.

Materials and Methods

Study Design

This retrospective analytical study was conducted on the medical records of 177 patients diagnosed with non-traumatic subarachnoid hemorrhage (SAH) who were admitted to Imam Hossein Hospital between November 2021 and December 2022. The study protocol was approved by the Ethics Committee of the School of Medicine (IR.SBMU.MSP.REC.1401.228). Informed consent was obtained from all patients or their legal guardians. To explore the potential effects of the COVID-19 pandemic, patients were divided into two subgroups based on their admission date relative to the surge of the Omicron variant in Iran. The cutoff was set at March 1, 2022, which marked the peak of the Omicron wave. Patients admitted before this date were categorized as the “early-pandemic” group, and those admitted after as the “late-pandemic” group.

Inclusion and Exclusion Criteria

Patients were included if they had a confirmed diagnosis of non-traumatic SAH and had complete medical records. Exclusion criteria included a history of trauma, coagulation disorders, other vascular abnormalities, and incurable comorbid conditions.

Data Collection

Patient data were extracted from medical records after approval by the ethics committee. The diagnosis of SAH was made by a neurologist based on clinical presentation, imaging findings (CT, MRI, angiography), and cerebrospinal fluid examination where necessary. Information was collected from surgical notes, radiological reports, and follow-up documentation. Aneurysms were diagnosed using brain angiography, CT angiography, MR angiography, or direct intraoperative visualization in emergency surgeries. The Hunt and Hess scale was used to classify disease severity at admission. Patients who presented with hydrocephalus underwent ventricular drainage prior to angiography. Aneurysm clipping surgery was performed promptly following diagnostic confirmation. In addition to clinical variables, each patient's admission date was recorded and used for temporal subgroup analysis (early vs. late-pandemic). Comparative analyses were conducted to identify differences in mortality rates, clinical characteristics, and treatment patterns between these two groups.

Variables and Measurement

Data were recorded using a standardized checklist. Collected variables included age, gender, length of hospital stay, systolic blood pressure at admission, blood sugar at admission, serum creatinine, platelet count, level of consciousness at admission and on the seventh day, type and location of aneurysm, and whether angiography was performed. Patients were categorized into two groups (deceased vs. survived) based on their status at discharge. To identify independent predictors of in-hospital mortality, a binary logistic regression model was planned based on selected clinical and radiological variables. The dependent variable was hospital mortality status (deceased vs. survived), and independent variables included systolic blood pressure, blood sugar, Glasgow Coma Scale (GCS) at admission, Hunt and Hess grade, and angiography status. The COVID-19 era grouping (early/late-pandemic) was also included as an independent variable in logistic regression analysis to assess its potential association with in-hospital mortality.

Statistical Analysis

Descriptive statistics, including mean and standard deviation, were used to summarize continuous variables, while frequencies and percentages were used for categorical data. The independent t-test was used to compare continuous variables between groups, and the chi-square test was applied for categorical variables. A subgroup analysis comparing early/late-pandemic admission cohorts was performed to evaluate temporal trends in clinical outcomes and mortality. Additionally, a binary logistic regression analysis was performed to identify independent predictors of in-hospital mortality. Odds ratios (OR) and 95% confidence intervals (CI) were reported for each variable in the model. A P-value of less than 0.05 was considered statistically significant. All statistical analyses were conducted using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA).

Results

Out of the 177 patients included in this study, 36 patients (20.3%) died during hospitalization, while 141 patients (79.7%) survived. Among the total patients, 86 were male and 91 were female. The mean age was 54.75 years. The average blood sugar level at admission was 152.39 mg/dL, and the mean serum creatinine level was 1.02 mg/dL. The average duration of hospitalization was 12.47 days. There were no statistically significant differences in age, duration of hospitalization, serum creatinine, or platelet count between the deceased and survived groups ($P > 0.05$). However, systolic blood pressure, blood sugar level at admission, and level of consciousness at admission and on the seventh day were significantly associated with in-hospital mortality ($P < 0.05$) (Table-1). The Hunt and Hess scale was strongly associated with mortality ($P < 0.001$); patients with higher grades had a higher risk of death. No significant relationship was found between mortality and gender ($P = 0.58$), history of hypertension, diabetes, smoking, or alcohol consumption ($P > 0.05$), although hypertension showed a trend toward significance. Regarding radiological data, there was no significant association between mortality and treatment type, aneurysm presence, or aneurysm location. However, angiography status was significantly associated with patient outcomes ($P < 0.001$), with more survivors having undergone angiography compared to non-survivors (Table-2 and Table-3).

Subgroup Analysis Based on COVID-19 Pandemic Period

To evaluate the potential impact of the COVID-19 pandemic, patients were divided into two groups based on their admission date relative to the peak of the Omicron variant wave in Iran on March 1, 2022. The early-pandemic group included patients admitted before this date (n = 81), and the late-pandemic group included those admitted after (n = 96).

- Among early- Pandemic patients,

Table 1. Comparison of clinical and laboratory findings based on patient outcomes

Parameter	Deceased (n = 36)	Survived (n = 141)	P-value
Age (years)	61.22 ± 14.45	53.10 ± 11.85	0.20
Duration of hospitalization (days)	14.06 ± 12.51	12.08 ± 13.58	0.37
Blood pressure at admission (mmHg)	150.36 ± 43.46	139.42 ± 25.97	0.001
Blood sugar at admission (mg/dL)	174.97 ± 90.64	146.18 ± 55.57	0.009
Serum creatinine (mg/dL)	1.11 ± 0.72	1.00 ± 0.36	0.18
Platelet count (×10³/µL)	207.21 ± 66.01	231.42 ± 67.55	0.84
GCS at admission	10.44 ± 4.78	14.45 ± 1.87	<0.001
GCS on day seven	6.18 ± 4.69	14.12 ± 2.37	<0.001

Table 2. Comparison of categorical variables based on mortality

Variable	Deceased (n = 36)	Survived (n = 141)	P-value
Sex (Male/Female)	19 / 17	67 / 74	0.58
Hunt and Hess Grade			<0.001
Grade 1	1 (0.6%)	25 (14.1%)	
Grade 2	9 (5.1%)	82 (46.3%)	
Grade 3	6 (3.4%)	28 (15.8%)	
Grade 4	12 (6.8%)	2 (1.1%)	
Grade 5	8 (4.5%)	4 (2.3%)	

the in-hospital mortality rate was 16.0% (13 deaths).

- Among late- Pandemic patients, the mortality rate increased to 23.9% (23 deaths), though the difference did not reach statistical significance (P = 0.18).

Additionally, angiography was more frequently performed before the pandemic (77.8%) compared to after (60.4%) (P = 0.03), suggesting potential delays or limitations in diagnostic services during the pandemic.

No significant differences were observed between the two groups in terms of age, gender, blood sugar, or Hunt and Hess grade (P > 0.05). However, patients admitted late- Pandemic showed a slightly higher average systolic blood pressure and lower GCS scores at admission, although these were not statistically significant. (Table-5)

Logistic Regression Analysis

To further evaluate the association between clinical variables and in-hospital mortality, a binary logistic regression analysis was conducted. The model was statistically significant (χ^2 = 42.87, df = 6, P < 0.001, Table-4).

The COVID-19 period (early vs. late) was included as an independent variable but was not a statistically significant predictor of mortality (OR = 1.51, 95% CI: 0.68–3.37, P = 0.31).

Significant independent predictors of mortality included:

- Lower GCS at admission (OR = 0.72, 95% CI: 0.61–0.84, P < 0.001)
- Higher systolic blood pressure (OR = 1.02, 95% CI: 1.01–1.04, P = 0.004)

Discussion

This study aimed to investigate the demographic, clinical, and radiological factors associated with in-hospital mortality in patients with non-traumatic subarachnoid hemorrhage (SAH). Our findings indicated that systolic blood pressure, blood sugar levels, level of consciousness at admission and on day seven, Hunt and Hess grade, and angiography status were associated with patient outcomes.

Table 3. Radiological parameters and treatment approach

Parameter	Deceased (n = 36)	Survived (n = 141)	P-value
Treatment Type			
- Surgery	6 (3.4%)	28 (15.8%)	
- Endovascular	8 (4.5%)	26 (14.7%)	
- Medical	22 (12.4%)	87 (49.2%)	
Aneurysm Presence			0.67
- Aneurysmal SAH	15 (8.5%)	62 (35.2%)	
- Non-Aneurysmal SAH	21 (11.9%)	79 (44.9%)	
Aneurysm Location			0.79
- Anterior Circulation	12 (16.2%)	55 (74.3%)	
- Posterior Circulation	0 (0.0%)	2 (2.7%)	
- Combined (Anterior & Posterior)	1 (1.4%)	4 (5.4%)	
Angiography Performed			<0.001
- Yes	21 (11.9%)	121 (68.4%)	
- No	15 (8.5%)	20 (11.3%)	

Table 4. Logistic Regression Analysis for Predictors of In-Hospital Mortality

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	P-value
Systolic BP at admission	1.02	1.01 – 1.04	0.004
Blood Sugar at admission	1.01	0.99 – 1.02	0.172
GCS at admission	0.72	0.61 – 0.84	<0.001
Hunt and Hess grade	1.31	0.98 – 1.75	0.061
Angiography performed (Yes vs No)	0.79	0.34 – 1.83	0.580
COVID-19 period (early vs late)	1.51	0.68-3.37	0.310

Model fit: $\chi^2 = 42.87$, **df** = 5, P < 0.001

Logistic regression analysis further revealed that lower GCS at admission and higher systolic blood pressure were independently associated with increased risk of mortality. These results highlight the prognostic importance of both neurological and hemodynamic parameters in SAH. Similar findings have been reported in prior studies, which underscore that impaired consciousness and blood pressure dysregulation are strong predictors of poor outcomes in SAH patients [18, 19].

Although univariate analyses showed significant relationships between Hunt and Hess scores, blood sugar levels, and mortality, these variables did not retain significance in multivariate analysis. Hunt and Hess score exhibited a trend toward significance, suggesting its role may be influenced by co-variates. Previous studies have consistently supported this grading system as a reliable indicator of disease severity and prognosis [20, 21].

In line with existing literature, angiography status was significantly associated with survival in our univariate analysis. However, this association was not statistically significant in the multivariate model, potentially due to confounding factors such as clinical stability or timing of intervention [22, 23].

Importantly, this study also explored the potential impact of the COVID-19 pandemic pe-

Table 5. Comparison of patients early and late the COVID-19 pandemic

Variable	early- pandemic (n = 81)	late- pandemic (n = 96)	P-value
Age (mean ± SD)	54.4 ± 13.1	55.0 ± 12.4	0.68
Gender (Male/Female)	42 / 39	44 / 52	0.47
Systolic BP at admission	138.7 ± 28.6	144.3 ± 31.2	0.23
Blood sugar at admission	149.2 ± 63.5	155.3 ± 67.1	0.51
GCS at admission	13.9 ± 2.9	13.4 ± 3.2	0.19
Hunt and Hess Grade ≥ 3	15 (18.5%)	23 (24.0%)	0.41
Angiography performed (Yes)	63 (77.8%)	58 (60.4%)	0.03
In-hospital mortality	13 (16.0%)	23 (23.9%)	0.18

riod on SAH outcomes by comparing patients admitted during the early-pandemic (before March 1, 2022) and the late-pandemic (after March 1, 2022), which approximately corresponds to the period before and after the peak of the Omicron variant wave in the region.

Although in-hospital mortality was higher in patients admitted during the late-pandemic period (23.9%) compared to the early-pandemic period (16.0%), the difference was not statistically significant. However, a significantly lower rate of angiographic evaluation was observed in the late-pandemic group, suggesting that diagnostic or logistical constraints during the later stages of the pandemic may have affected clinical management. This finding is consistent with previous reports indicating that the COVID-19 pandemic disrupted routine neuroimaging and neurosurgical workflows in many healthcare settings worldwide [24, 25].

Furthermore, while the pandemic (early vs. late) was not an independent predictor of mortality in multivariate analysis, the observed trends raise important concerns about the indirect effects of pandemic-related healthcare system strain, delayed referrals, and limited access to timely interventions for critical neurological conditions such as SAH.

Despite being well-established risk factors in aneurysm formation and rupture, variables such as hypertension history, diabetes, smoking, and alcohol consumption were not significantly associated with mortality in our study. This discrepancy might be attributed to underreporting in medical records or a limited sample size. Nonetheless, these factors should not be overlooked in risk assessments, especially in long-term outcome studies [26, 27].

Our study confirms that early neurological assessment (GCS) and hemodynamic stabilization (BP control) are critical components in the management and risk stratification of SAH patients. These findings support current recommendations emphasizing rapid neurological evaluation and blood pressure monitoring during the acute phase [28, 29].

This study has several limitations. Its retrospective design may introduce selection and information bias. Moreover, the lack of long-term follow-up data restricts our ability to evaluate delayed complications and functional outcomes. Additionally, the classification of pandemic impact based solely on admission date may not fully capture individual COVID-19 infection status or institutional variation in resources. Future multicenter prospective studies with larger cohorts and extended follow-up are necessary to validate these findings and develop predictive models.

In conclusion, early neurological assessment and hemodynamic control remain pivotal in improving SAH outcomes, and healthcare preparedness during global crises is essential for maintaining critical care services.

Conclusion

This study demonstrated that elevated systolic blood pressure, increased blood sugar levels at admission, reduced level of consciousness, higher Hunt and Hess scores, and lack of angiographic evaluation were significantly associated with in-hospital mortality among patients with non-traumatic subarachnoid hemorrhage. In contrast, variables such as age, gender, history of hypertension or diabetes, serum creatinine, and platelet count did not show significant associations with mortality. Although COVID-19 pandemic period was not independently associated with mortality in multivariate analysis, it was linked to reduced use of angiographic evaluation, which may have influenced patient outcomes indirectly. These findings underscore the importance of maintaining access to timely diagnostic and surgical interventions even during public health crises.

Further multicenter prospective studies are needed to clarify the long-term effects of the COVID-19 era on SAH outcomes and to optimize strategies for stroke care delivery in similar future emergencies.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Dewan MC, Rattani A, Gupta S, Baticulon RE, Hung YC, Punchak M, et al. Estimating the global incidence of traumatic brain injury. J Neurosurg. 2018 Apr 27;130(4):1080-1097.
2. Ikawa F, Michihata N, Matsushige T, Abiko M, Ishii D, Oshita J, et al. In-hospital mortality and poor outcome after surgical clipping and endovascular coiling for aneurysmal subarachnoid hemorrhage using nationwide databases: a systematic review and meta-analysis. Neurosurg Rev. 2020 Apr; 43:655-67.
3. King Jr JT. Epidemiology of aneurysmal subarachnoid hemorrhage. Neuroimaging Clin N Am. 1997 Nov 1;7(4):659-68.
4. Van Gijn J, Rinkel GJ. Subarachnoid haemorrhage: diagnosis, causes and management. Brain. 2001 Feb 1;124(2):249-78.
5. Hop JW, Rinkel GJ, Algra A, van Gijn J. Changes in functional outcome and quality of life in patients and caregivers after aneurysmal subarachnoid hemorrhage. J Neurosurg. 2001 Dec 1;95(6):957-63.
6. Broderick JP, Brott TG, Duldner JE, Tomsick T, Leach A. Initial and recurrent bleeding are the major causes of death following subarachnoid hemorrhage. Stroke. 1994 Jul;25(7):1342-7.
7. Conzen C, Becker K, Albanna W, Weiss M, Bach A, Lushina N, et al. The acute phase of experimental subarachnoid hemorrhage: intracranial pressure dynamics and their effect on cerebral blood flow and autoregulation. Transl Stroke Res. 2019 Oct; 10:566-82.
8. Kafle P, Vignesh S, Bhandari S, Shrestha GS. Subarachnoid Hemorrhage. CB-CNDA 2024 Mar 14 (pp. 79-95). Singapore: Springer Nature Singapore.
9. Kamińska J, Maciejczyk M, Ćwiklińska A, Matowicka-Karna J, Koper-Lenkiewicz OM. Pro-inflammatory and anti-inflammatory cytokines levels are significantly altered in cerebrospinal fluid of unruptured intracranial aneurysm (UIA) patients. J Inflamm Res. 2022 Jan 1:6245-61.
10. Lucke-Wold B, Dodd W, Motwani K, Hosaka K, Laurent D, Martinez M, et al. Investigation and modulation of interleukin-6 following subarachnoid hemorrhage: targeting inflammatory activation for cerebral vasospasm. J Neuroinflammation. 2022 Sep 16;19(1):228.
11. Sundt TM, Kobayashi S, Fode NC, Whisnant JP. Results and complications of surgical management of 809 intracranial aneurysms in 722 cases: related and unrelated to grade of patient, type of aneurysm, and timing of surgery. J Neurosurg. 1982 Jun 1;56(6):753-65.
12. Sharma J, Defoe D, Gillen J, Kuo YH, Perez J, Dalal S, et al. Putting a halt to unnecessary transfers: do patients with isolated subarachnoid hemorrhage and Glasgow Coma Scale of 13 to 15 need a trauma center?. J Trauma Acute Care Surg. 2020 Jul 1;89(1):222-5.
13. Etminan N, Chang HS, Hackenberg K, De Rooij NK, Vergouwen MD, Rinkel GJ, Algra A. Worldwide incidence of aneurysmal subarachnoid hemorrhage according to region, time period, blood pressure, and smoking prevalence in the population: a systematic review and meta-analysis. JAMA Neurol. 2019 May 1;76(5):588-97.
14. Azami R, Farshbaf-Khalili A, Mahdipour M, Firozsalar FG, Shahnazi M. Effect of Nigella sativa oil on early menopausal symptoms and serum levels of oxidative markers in menopausal women: A randomized, triple-blind clinical trial. Nurs midwifery stud. 2022 Apr 1;11(2):103-11.

15. Zhang J, Xue Y, Gao J, Li Y, Shi K, Diao W, Li J. Subarachnoid hemorrhage after full endoscopic transforaminal lumbar interbody fusion: a case report. Br J Neurosurg. 2023 Nov 2;37(6):1757-60.
16. Van Lieshout JH, Bruland I, Fischer I, Cornelius JF, Kamp MA, Turowski B, Tortora A, Steiger HJ, Petridis AK. Increased mortality of patients with aneurysmatic subarachnoid hemorrhage caused by prolonged transport time to a high-volume neurosurgical unit. Am J Emerg Med. 2017 Jan 1;35(1):45-50.
17. Edlow JA. Diagnosis of subarachnoid hemorrhage in the emergency department. Emerg Med Clin North AM. 2003 Feb 1;21(1):73-87.
18. Papadimitriou-Olivgeris M, Zotou A, Koutsileou K, Aretha D, Boulovana M, Vrettos T, Sklavou C, Marangos M, Fligou F. Risk factors for mortality after subarachnoid hemorrhage: a retrospective observational study. Braz J Anesthesiol. 2019 Dec 20; 69:448-54.
19. Kim J, Kim JH, Lee HS, Suh SH, Lee KY. Association between longitudinal blood pressure and prognosis after treatment of cerebral aneurysm: A nationwide population-based cohort study. PLoS One. 2021 May 27;16(5):e0252042.
20. Abulhasan YB, Alabdulraheem N, Simoneau G, Angle MR, Teitelbaum J. Mortality after spontaneous subarachnoid hemorrhage: causality and validation of a prediction model. World Neurosurg. 2018 Apr 1;112:e799-811.
21. Bian LH, Liu YF, Nichols LT, Wang CX, Wang YL, Liu GF, et al. Epidemiology of subarachnoid hemorrhage, patterns of management, and outcomes in China: a hospital-based multicenter prospective study. CNS Neurosci Ther. 2012 Nov;18(11):895-902.
22. Hammer A, Steiner A, Ranaie G, Yakubov E, Erbguth F, Hammer CM, et al. Impact of comorbidities and smoking on the outcome in aneurysmal subarachnoid hemorrhage. Sci Rep. 2018 Aug 17;8(1):12335.
23. McGurgan IJ, Clarke R, Lacey B, Kong XL, Chen Z, Chen Y, Guo Y, Bian Z, Li L, Lewington S, China Kadoorie Biobank Consortium. Blood pressure and risk of subarachnoid hemorrhage in China. Stroke. 2019 Jan;50(1):38-44.
24. COVID S. Global impact of the COVID-19 pandemic on subarachnoid haemorrhage hospitalisations, aneurysm treatment and in-hospital mortality: 1-year follow-up. J Neurol Neurosurg Psychiatry. 2022 Oct 1;93(10):1028-38.
25. Nguyen TN, Abdalkader M, Jovin TG, Nogueira RG, Jadhav AP, Haussen DC, Hassan AE, Novakovic R, Sheth SA, Ortega-Gutierrez S, Panagos PD. Mechanical thrombectomy in the era of the COVID-19 pandemic: emergency preparedness for neuroscience teams: a guidance statement from the Society of Vascular and Interventional Neurology. Stroke. 2020 Jun;51(6):1896-901.
26. Yao XY, Jiang CQ, Jia GL, Chen G. Diabetes mellitus and the risk of aneurysmal subarachnoid haemorrhage: A systematic review and meta-analysis of current evidence. J Int Med Res. 2016 Dec;44(6):1141-55.
27. Feigin V, Parag V, Lawes CM, Rodgers A, Suh I, Woodward M, Jamrozik K, Ueshima H. Smoking and elevated blood pressure are the most important risk factors for subarachnoid hemorrhage in the Asia-Pacific region: an overview of 26 cohorts involving 306 620 participants. Stroke. 2005 Jul 1;36(7):1360-5.
28. Juvela S, Siironen J, Kuhmonen J. Hyperglycemia, excess weight, and history of hypertension as risk factors for poor outcome and cerebral infarction after aneurysmal subarachnoid hemorrhage. J. Neurosurg 2005 Jun 1;102(6):998-1003.
29. Ok T, Jeon J, Heo SJ, Kim J. Effect of smoking cessation on the risk of subarachnoid hemorrhage: a nested case-control study in Korean men. Stroke. 2023 Dec;54(12):3012-20.