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Original Article

Evaluation of unruptured aneurysm scoring systems and ratios in subarachnoid hemorrhage patients with multiple intracranial aneurysms

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ABSTRACT

Background: This study aims to appraise aneurysm scores and ratios' ability to discriminate between ruptured aneurysms and unruptured intracranial aneurysms (UIAs) in subarachnoid hemorrhage (SAH) patients harboring multiple intracranial aneurysms (MICAs). We, then, investigate the most frequent risk factors associated with MICAs.

Methods: We retrospectively applied unruptured intracranial aneurysm treatment score (UIATS) and population hypertension age size of aneurysm earlier SAH from another aneurysm site of aneurysm (PHASES) score, aspect, and dome-to-neck ratio to the 59 consecutive spontaneous SAH patients with MICAs admitted between January 2000 and December 2015 to the Department of Neurosurgery of the University Hospital Center "Hôpital des Spécialités" of Rabat (Morocco). Patients with at least two intracranial aneurysms (IAs) confirmed on angiography were included in the study.

Results: Fifty-nine patients were harboring 128 IAs. The most frequent patient-level risk factors were arterial hypertension (AHT) 30.5 % (n = 18) and smoking status 22.0 % (n = 13). A PHASES score recommended treatment in 52 of 60 ruptured aneurysms and in six of 68 UIAs with a sensitivity of 31.67% and a specificity of 76.47%. UIATS recommended treatment in 26 of 62 ruptured aneurysms and in 35 of 55 UIAs with a sensitivity of 41.9% and a specificity of 63.6%. Aspect ratio recommended treatment in 60 of 60 ruptured aneurysms and in 63 of 68 UIAs with a sensitivity of 100% and a specificity of 88.24%. Dome-to-neck ratio recommended treatment in 45 of 60 ruptured aneurysms and in 48 of 68 UIAs with a sensitivity of 80% and a specificity of 63.24%. The aspect ratio (area under the curve [AUC] = 0.953) AUC > 0.8 has a higher discriminatory power between ruptured aneurysms and UIAs.

Conclusion: AHT and smoking status were the most common risk factors for intracranial multiple aneurysms and the aspect ratio and PHASES score were the most powerful discrimination tools between ruptured aneurysms and the UIAs.

Keywords: Multiple intracranial aneurysms, Ruptured aneurysm, Scores and ratio, Unruptured aneurysm

INTRODUCTION

Multiple intracranial aneurysm (MICA) counts approximately 30% of patients with intracranial aneurysms (IAs).[3,19]

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In the case of MICA, identifying the ruptured IA is increasingly important in such an era; here, patients are mostly treated by endovascular means, it is difficult to confirm visually the source of hemorrhage, and aneurysms are usually treated individually.[9,19]

However, Orning *et al.*[16] demonstrated in their previous study that a definitive hemorrhage pattern (localized to one IA) could accurately delineate the ruptured IAs, but in approximately half of the patients with multiple aneurysms, the hemorrhage pattern cannot delineate the ruptured IA, and in such cases, rupture identification relies on angiographic findings, such as IA size, shape, and location.[9,14]

Rajabzadeh-Oghaz *et al.*[20] reported recently that for the identification of ruptured IAs in patients with subarachnoid hemorrhage (SAH) with MICA, size ratio (SR) height max (SRHmax) is the best predictor among individual morphologic parameters, including location and type and hemodynamic parameters. Furthermore, they conclude that the composite models rupture identification model with computational fluid dynamics had a better positive predictive value in identifying rupture IAs among MICA than the rupture identification model with morphologic parameter.[4,11,13,16,18-20,23,26,27]

However, MICA management is still challenging nowadays whether revealed by SAH or not, and the indication of adequate treatment might be case by case after a meeting between neurosurgeons or hybrid neurosurgeons and interventional neuroradiologist team.

This study aims to appraise aneurysm scores and ratios' ability to discriminate between ruptured aneurysms and unruptured intracranial aneurysms (UIAs) in SAH patients harboring MICAs. We, then, investigate the most frequent risk factors associated with MICAs.

MATERIALS AND METHODS

Ethics statement

The data collected during the study have been stored in a computer file in conformity with the Moroccan Data Protection Law, Decree n° 2-09-165 of May 21, 2009. The study consent was waived because this was a retrospective study with anonymized data collection.

Study population

This is a cohort retrospective single institutional review of patients diagnosed with spontaneous SAH, from January 2000 to December 2015 in the Department of Neurosurgery of the University Hospital Center "Hôpital des Spécialités" of Rabat (Morocco). Patients diagnosed with at least two IAs confirmed on angiography were included in this study. The ruptured aneurysms were pinpointed among SAH patients secondary to the aneurysmal rupture confirmed on the cerebral arteriography. We excluded all patients with single IAs, incomplete medical records, and all others who do not have a cerebral angiographic result in their record.

A total of 574 patients were admitted between January 2000 and December 2015 to the Department of Neurosurgery of the University Hospital Center "Hôpital des Spécialités" of Rabat (Morocco) with the diagnosis of spontaneous SAH. Of these, 59 (10.3%) patients were diagnosed with multiple aneurysms, harboring 128 aneurysms. Fifty (84.7%) patients were diagnosed with two, 8 (13.6%) patients with three, and only 1 (1.7%) patient with four aneurysms [Figure 1].

Data acquisition

Patient-level sociodemographic data (age and gender), medical history, risk factors, WFNS and Fisher grading, number of aneurysms per patient, clinical state, date of management, surgical, endovascular, and conservative treatment, complications, outcome, and follow-up as well as aneurysm level data such as size, neck, width, height, dome-to-neck ratio, topography of aneurysm, aspect ratio, ruptured aneurysm, and unruptured aneurysm were collected and tabulated in an Excel spreadsheet. IASCORE[1] website calculated the unruptured intracranial aneurysm treatment score (UIATS) and population hypertension age size of aneurysm earlier SAH from another aneurysm site of aneurysm (PHASES) scores

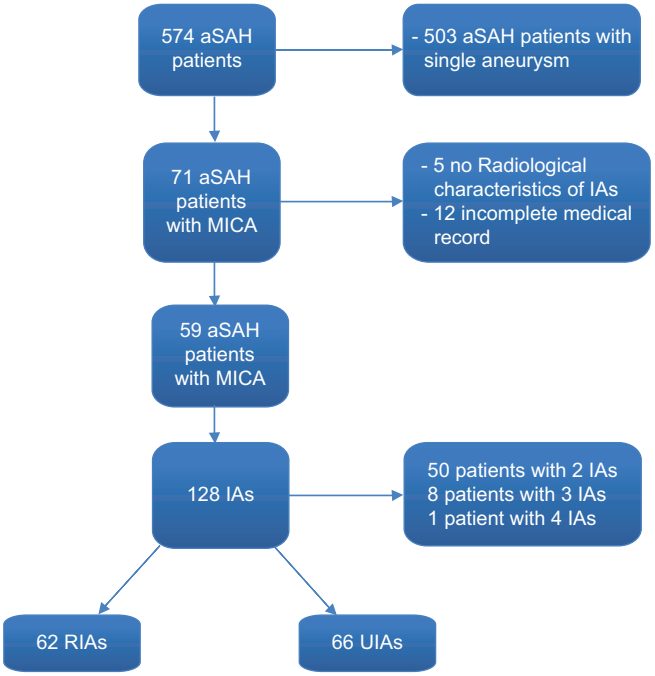

Figure 1: Diagram flowchart for patient selection. aSAH: aneurysmal subarachnoid hemorrhage, MICA: Multiple intracranial aneurysm, IAs: Intracranial aneurysms, RIAs: Ruptured intracranial aneurysms, UIAs: Unruptured intracranial aneurysms.

for inputs provided through a form. It also computes the estimated 5-year rupture rate according to the international study of unruptured intracranial aneurysm (ISUIA) study. Each aneurysm was tested separately for ISUIA and PHASES scores which resulted in separate recommendations for each aneurysm. The input clinical characteristics requested for each aneurysm are highlighted in Tables 1a and 1b.

Statistical analysis

Data analysis was performed using JAMOVI version 3.2.8. Differences in dome-to-neck ratio, aspect ratio, PHASES score, and UIATS between ruptured IAs and UIAs were determined by fitting linear mixed models with a patient-specific random intercept. The within-patient and between-patient standard deviations were estimated based on the fitted models. Regression coefficients were rescaled according to within-patient standard deviations to compare the ability of both ratios and scores to discriminate between ruptured aneurysms and UIAs in the same patient. In addition, we calculated areas under the receiver operating characteristic (ROC) curves for both ratios and scores for each patient's aneurysms and compared them statistically using the Likelihood ratio. Conditional logistic regression models were fitted to aneurysm type (ruptured aneurysm vs. UIA) to investigate the ability of the different aneurysm-specific characteristics of ratios and scores to discriminate between ruptured aneurysms and UIAs of the same patient. The likelihood ratio Chi-squared test and the Akaike information criterion were used to compare the models, and revised scores were generated based on the selected model coefficients. We, then, broke through the one-to-many matching of patients and compared the pool of 62 ruptured aneurysms to 66 UIAs to calculate sensitivity and specificity by applying the described score cutoffs. We similarly generated ROC curves to analyze the ability of each ratio and score to marginally discriminate between ruptured IAs and UIAs. All *P*-values are two-tailed. *P*-values below 0.05 were considered statistically significant.

Table 1a: Summary of characteristics of the study cohort.

Features	*n* (%)
Sex	
Male	22 (37.3)
Female	37 (62.7)
Age	
18–40	17 (28.8)
41–80	42 (71.2)
Risk factors	
Arterial hypertension	18 (30.5)
Smoking	13 (22)
Arterial hypertension and diabetes	7 (11.9)
Diabetes	7 (11.9)
Clinical presentation	
Meningeal syndrome	47 (79.7)
Epilepsy and cerebral palsy	7 (11.9)
Intracranial hemorrhage	4 (6.8)
Aphasia and cerebral palsy	1 (1.7)
Aneurysm count	
2	50 (84.7)
3	8 (13.6)
4	1 (1.7)
WFNS grading	
I	41 (69.5)
II	6 (10.2)
III	6 (10.2)
IV	5 (8.5)
V	1 (1.7)
Fisher grading	
I	9 (15.3)
II	16 (27.1)
III	10 (16.9)
IV	24 (40.7)
Evolution before treatment	
Asymptomatic	8 (13.6)
Vasospasm	7 (11.9)
Meningeal syndrome	44 (74.6)

n: number of cases

RESULTS

Patient cohort and aneurysms characteristics

The most frequent patient-level risk factors were arterial hypertension (AHT) 30.5% (n = 18), followed by current

Table 1b: Characteristics of treatment and outcome of MICA.

Features	*n* (%)	*P*-value
Surgical treatment	0.38±0.8[a]	
One clipped	28 (47.5)	<0.001
Two clipped	11 (18.6)	<0.001
Not clipped	20 (33.9)	<0.001
Endovascular treatment	0.32±0.53[a]	
One embolized	13 (22.0)	<0.001
Two embolized	1 (1.7)	<0.001
Not embolized	45 (76.3)	<0.001
Conservative treatment	0.16±0.37[a]	
Treated	49 (83.1)	<0.001
Not treated	10 (16.9)	<0.001
Evolution after treatment		
Cerebral palsy	7 (11.9)	0.998
Vasospasm	4 (6.8)	0.101
Septicemia	1 (1.7)	0.061
No complication	47 (79.7)	0.002
Outcome		
Alive	53 (89.8)	<0.001
Death	6 (10.2)	<0.001
Follow-up 12 months		
Exclude	51 (86.4)	<0.001
Permeable	8 (13.6)	<0.001

MICA: Multiple intracranial cerebral aneurysm, [a]Mean±Standard deviation, *n:* number of cases

smoking 22.0% (n = 13). Diabetes and combined arterial hypertension plus diabetes count for 11.9% (n = 7) for each. Forty-one (69.5%) patients presented with WFNS Grade I whereas 24 (40.7%) were Grade IV of Fisher. Interestingly, the multivariable survival analysis of Figure 2 reports vasospasm being the deadliest complication in aneurysmal SAH patients with a high mortality rate (heart rate [HR] = 11, $P < 0.05$). In a short-term follow-up, the overall patient with vasospasm is at risk of dying within 14 months after aneurysms ruptured. The number of patients at risk reduced over time and there were no more patients at risk over 18 months of follow-up.

Tables 1a and 1b highlighted the overall patients and aneurysms characteristics and 62 (48.4%) aneurysms were ruptured against 66 (51.6%) unruptured. The average dome-to-neck ratio was 2.62 ± 1.71 millimeters (mm) (95% confidence interval 2.32–2.92) with a range of 0.42–8.10 mm. Sixty-three aneurysms (49.2%) were found to have a wide neck with a dome-to-neck ratio <2 mm, this difference is statistically significant ($P < 0.001$). The prevalence of dome-to-neck ratio within aneurysm location exposes the middle cerebral artery holding the most important wide neck (<2 mm) in 65.8 % (n = 25) of cases. Table 2 shows the clinical and imaging features required for the calculation of the UIATS and PHASES score for ruptured IA and UIAs.

The UIATS recommends aneurysm treatment in 71 cases (55.5 %), conservative management in 46 cases (35.9%), and inconclusive in 11 cases (8.6 %). For the 66 UIAs, UIATS recommended aneurysm treatment in 35 (27.3%), conservative management in 25 (19.5%), and inconclusive in 6 (4.7%) cases. Among the 62 ruptured IAs, the mean estimated rupture rate over 5 years according to PHASES score was 1.25% ± 1.3. In 58 (45.3%) cases, the PHASES rupture rate over 5 years was <5% and >5% for only 4(3.1%) cases. A detailed overview of the UIATS and the distribution of the PHASES score for ruptured aneurysms and UIAs are shown in Table 2. The radiological characteristics of the 128 aneurysms as shown in Table 3 underline that the mean aspect ratio of 1.67 ± 1.40 was statistically significant for all locations and both groups of aneurysms of <1.6 and >1.6 aspect ratio. Almost 97% (60/62 ruptured) of the ruptured aneurysms showed an aspect ratio of more than 1.6, whereas more than 95% (63/66 unruptured) of the unruptured aneurysms showed an aspect ratio of <1.6. Notably, compared with the UIAs, the ruptured IAs were larger and had higher aspect ratios with $P < 0.05$.

UIATS and PHASES Score discrimination versus aspect and dome-to-neck ratio

The sensitivity and specificity of these variables were applied to the ruptured aneurysms and the UIAs, assuming that for ruptured aneurysms, the decision for treatment, and UIAs for conservative management would be correct. A PHASES score of ≥6 points was considered as a recommendation for treatment, a score of ≥1.5<6 (1.5; 6) indicated a low likelihood of aneurysm rupture. With these settings, the PHASES score recommended treatment in 52 of 60 ruptured aneurysms and 6 of 68 UIAs, resulting in a sensitivity of 31.67% and a specificity of 76.47%. UIATS recommended treatment when the number of points in favor of repair is ≥17 and the number of points in favor of conservative management is ≤10. With these settings, the UIATS recommended treatment in 26 of 62 ruptured aneurysms and 35 of 55 UIAs with a sensitivity of 41.9% and a specificity of 63.6%. Treatment is recommended when the aspect ratio is >1.6. With these settings, the aspect ratio recommended treatment in 60 of 60 ruptured aneurysms and 63 of 68 UIAs with a sensitivity of

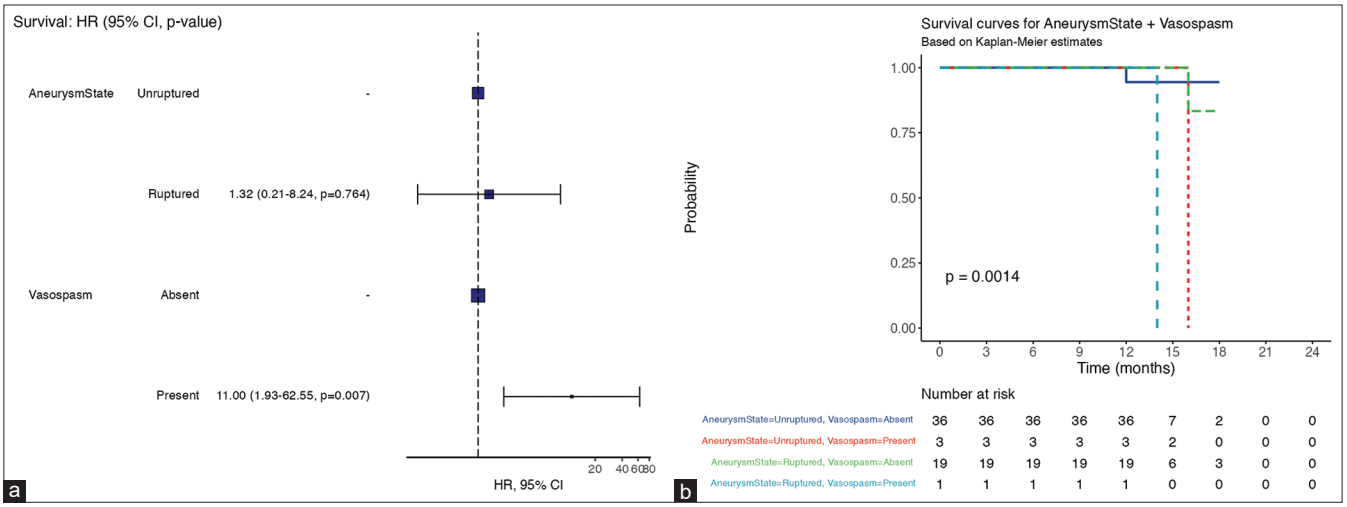

Figure 2: (a) Multivariable survival analysis showing statistically significant high mortality rate (heart ratio = 11, $P < 0.05$) among subarachnoid hemorrhage patients complicated with vasospasm. (b) In a short-term follow-up, the overall patient with vasospasm is at risk of dying within 14 months after aneurysms ruptured. HR: Hazard ratio, CI: Confident interval

Table 2: Predictors composing the PHASES score to estimate the 5-year aneurysm rupture rate.

PHASES aneurysm risk score				
Criteria	**Points**	**RIA *n* (%)**	**UIA *n* (%)**	***P*-value**
(P) Population		62	66	
North American, European (other than Finnish)	0	0	0	
Japanese	3	0	0	
Finnish	5	0	0	
(H) Hypertension				
No	0	34 (54.8)	39 (59.1)	0.018
Yes	1	28 (45.2)	27 (40.9)	0.015
(A) Age				
<70 years	0	57 (92)	65 (98.5)	0.190
≥70 years	1	5 (8.1)	1 (1.5)	0.804
(S) Size of aneurysm				
<7.0 mm	0	52 (83.9)	55 (83.3)	<0.001
7.0–9.9 mm	3	8 (12.9)	6 (9.1)	<0.001
10.0–19.9 mm	6	2 (3.2)	6 (9.1)	<0.001
≥20 mm	10	0	0	
(E) Earlier SAH from another aneurysm				
No	0	0	0	
Yes	1	0	0	
(S) Site of aneurysm				
ICA	0	32 (51.6)	14 (21.2)	<0.001
MCA	2	6 (9.7)	32 (48.5)	<0.001
ACA/PcoA/Posterior circulation	4	24 (38.7)	20 (30.3)	<0.001

SAH: Subarachnoid hemorrhage, ICA: Internal carotid artery, MCA: Middle cerebral artery, ACA: Anterior cerebral arteries including the anterior cerebral artery, anterior communicating artery, and pericallosal artery. PcoA: Posterior communicating artery, Posterior circulation including the vertebral artery, basilar artery, cerebellar arteries, and posterior cerebral artery. To calculate the PHASES risk score for an individual, the number of points associated with each indicator can be added up to obtain the total risk score, RIA: Ruptured intracranial aneurysm, UIA: Unruptured intracranial aneurysm, *n*: number of cases

Table 3: Radiological characteristics of the 128 intracranial aneurysms with the prevalence within locations.

Features	**ICA-46 *n* (%)**	**MCA-38 *n* (%)**	**ACA/PcoA/ Posterior circ.-44 *n* (%)**
Size (mm)			
<7.0 mm	46 (35.9)	23 (18)	38 (29.7)
7.0–9.9 mm	0	8 (6.3)	6 (4.7)
10.0–19.9 mm	0	7 (5.5)	0
≥20 mm	0	0	0
Aspect ratio			
>1.6	33 (25.8)	8 (6.3)	24 (18.8)
<1.6	13 (10.2)	30 (23.4)	20 (15.6)
Dome-to-neck ratio			
>2	30 (65.2)	13 (34.2)	22 (50)
<2	16 (34.8)	25 (65.8)	22 (50)

ICA-46: 46 aneurysms located on the internal carotid artery, MCA-38: 38 aneurysms located on the middle cerebral artery, ACA/PcoA/Posterior circ.–44: 44 aneurysms located on the anterior cerebral artery/posterior communicating artery/posterior circulation. The aneurysm is qualified as having a wide neck when the Dome-To-Neck Ratio is <2 mm. When the Aspect ratio >1.6, the aneurysm should be treated because it has the characteristics to rupture. *n:* number of cases

100% and a specificity of 88.24%. Treatment is recommended when the dome-to-neck ratio is <1.8. With these settings, the dome-to-neck ratio recommended treatment in 45 of 60 ruptured aneurysms and 48 of 68 UIAs with a sensitivity of 80% and a specificity of 63.24% [Table 4 and Figure 3].

To investigate the scores' ability to discriminate between ruptured aneurysms and UIAs, a ROC curve analysis was performed; the results are shown in [Figure 4]. Table 4 gives more details about the areas under the ROC curves (area under the curve [AUC]) for UIATS, PHASES score, aspect, and dome-to-neck ratio. Taken together, the findings indicate that the aspect ratio (AUC = 0.953) AUC >0.8 has a higher discriminatory power between ruptured aneurysms and UIAs; making the aspect ratio the most powerful discrimination tools for ruptured aneurysms and the UIAs followed by dome-to-neck ratio (AUC = 0.781), UIATS/repair (AUC = 0.589), UIATS/conservative (AUC = 0.49), and PHASES score (AUC = 0.422).

DISCUSSION

Key findings

The most frequent patient-level risk factors for MICAs were AHT 30.5% (n = 18) and smoking status 22.0% (n = 13).

Table 4: Sensitivity and specificity of intracranial aneurysm rupture predictors.

Variables	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC	Likelihood ratio		Diagnosis accuracy
						−LR	+LR	
UIATS-repair	33.33	91.18	76.92	60.78	0.589	0.885	1.15	Low
UIATS-conservative	91.67	17.65	49.55	70.59	0.495	0.885	1.15	Low
PHASES risk score	31.67	76.47	54.29	55.91	0.422	0.951	1.51	Low
Aspect ratio	100	88.24	88.24	100	0.953	0.00	13.6	Very accurate
Dome neck ratio	80	63.24	65.75	78.18	0.781	0.354	2.55	Moderate

PPV: Positive predictive value, NPV: Negative predictive value, AUC: Area under the curve, UIATS: Unruptured intracranial aneurysm treatment score, PHASES: Population hypertension age size of aneurysm earlier SAH from another aneurysm site of the aneurysm

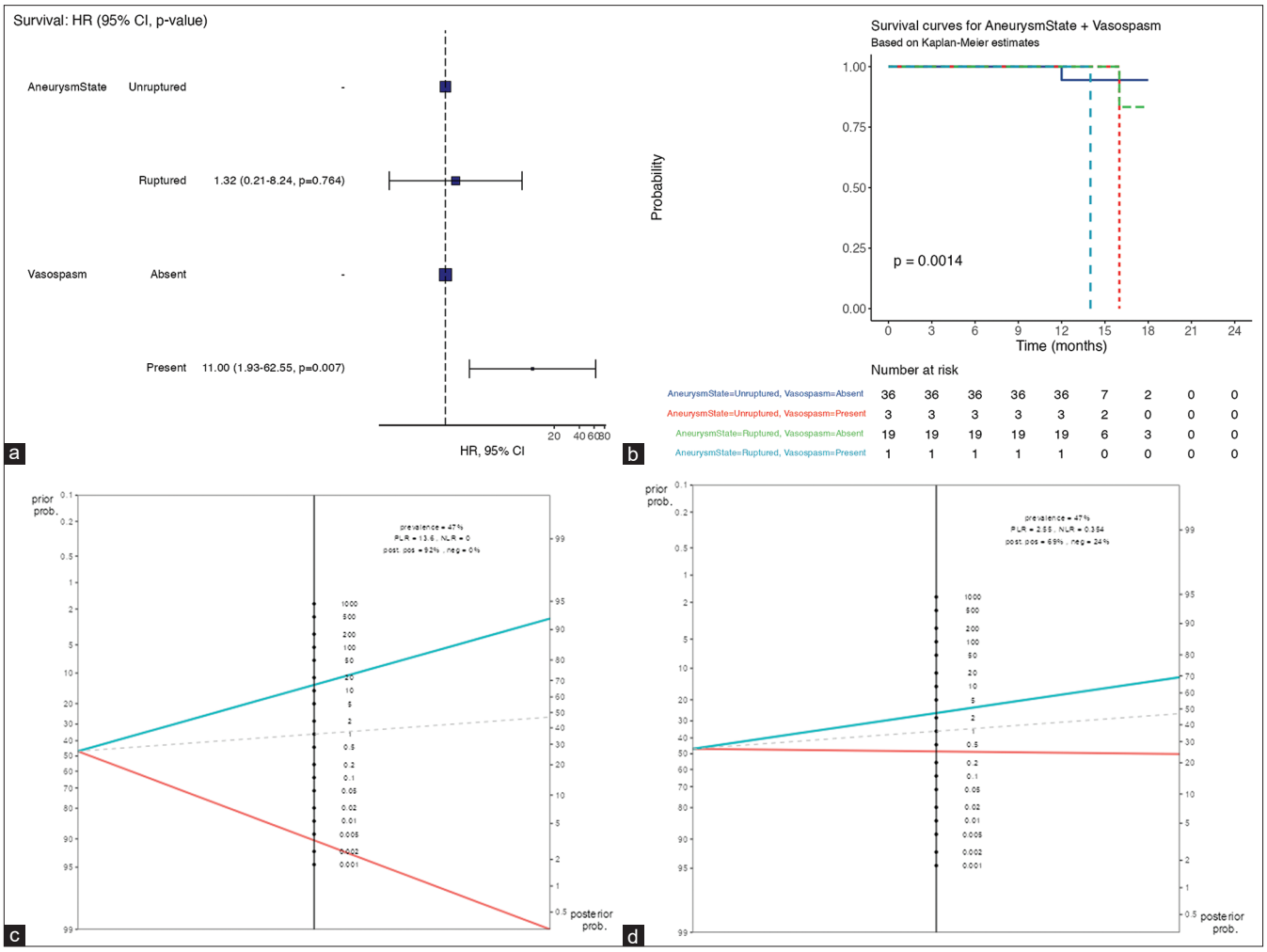

Figure 3: Fagan nomogram (a) the UIATS recommendation for aneurysm repair/conservative treatment was from 47% to 49% of cases when rupture is predicted (positive likelihood ratio 1.15; negative likelihood ratio 0.885). (b) The prevalence of PHASES risk score to predict aneurysm rupture was from 47% to 57% when the rupture happened as predicted (positive likelihood ratio 1.51; negative likelihood ratio 0.951). (c) The prevalence of aspect ratio to predict aneurysm rupture was 47% at the pretest and 92% post-test when the rupture happened as predicted (positive likelihood ratio 13.6; negative likelihood ratio 0.00). (d) The prevalence of dome-to-neck ratio to predict aneurysm rupture was 47% at the pretest and 69% post-test when the rupture happened as predicted (positive likelihood ratio 2.55; negative likelihood ratio 0.354). UIATS: Unruptured intracranial aneurysm treatment score, PHASES: Population hypertension age size of aneurysm earlier SAH from another aneurysm site of aneurysm. HR: Hazard ratio, CI: Confident interval, PLR: Positive likelihood ratio, NLR: Negative likelihood ratio

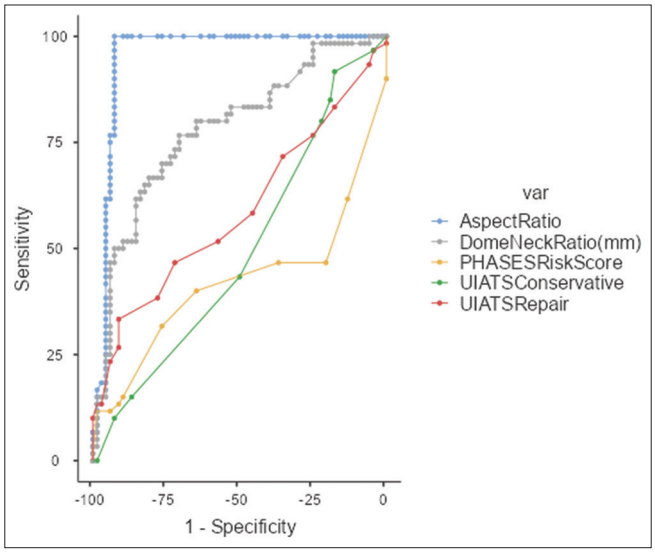

Figure 4: The ROC curve of UIATS recommendation for repair/conservative treatment and PHASES risk score is very far from the perfect discrimination point. The dome-to-neck ratio is closer to the previous curves but it's AUC = 0.78 < 0.8. Meanwhile, the aspect ratio ROC curve passes on the perfect discrimination point with an AUC = 0.95 > 0.8. ROC: Receiver operating characteristic, UIATS: Unruptured intracranial aneurysm treatment score, PHASES: Population hypertension age size of aneurysm earlier SAH from another aneurysm site of aneurysm, AUC: Area under the curve.

Treatment is recommended when the aspect ratio is >1.6. The aspect ratio (AUC = 0.953) AUC >0.8 is the most powerful discrimination tool between ruptured aneurysms and the UIAs.

Implications

Hadjiathanasiou *et al.*[8] reported AHT and smoking as risk factors, respectively, in 44% and 35% of their cohort of 252 patients. In our MICA series, our findings are not so far from theirs with 30.5% for AHT and 22% for smoking. These confirm whether the sample is large or small, smoking and AHT remain the common risk factors in MICA. Regarding the incidence of MICA, Dharshini *et al.*[5] reported previously 8.1% of MICA in their incidence which is not so far as in our series where we found 10.3% of incidence. Therefore, searching MICA should be systematic in case of SAH due to a ruptured aneurysm or in case of incidental discovery of aneurysm.

Vasospasm is a complication with a higher risk of mortality (HR = 11, $P < 0.05$) within 14 months in our cohort of ruptured aneurysms with MICA patients. On the other hand, Baumann *et al.*[2] reported vasospasm as the common complication in their series (44%), Filipce and Caparoski[7] found also that patients with vasospasm have less good outcomes compared to those without vasospasm (7.10% vs. 54%, $P < 0.001$), and Sharma *et al.*[22] found vasospasm or hydrocephalus such as factors associated with unfavorable outcomes ($P = 0.04$).[5,15,24]

Previously, Mocco *et al.*,[12] reported that aspect ratio, daughter sacs, multiple lobes, aneurysm angle, neck diameter, parent vessel diameter, and calculated aneurysm volume were not statistically significant predictors of rupture, they found on multivariate analysis that perpendicular height was the only significant predictor of rupture (Chi-square 7.1, $P = 0.008$).[2,8,22] Furthermore, several prospective and retrospective studies suggested that SR is a predictor of UIA rupture.[12,17] In our series, the aspect ratio recommended treatment in 60 of 60 ruptured aneurysms and 63 of 68 UIAs with a sensitivity of 100% and a specificity of 88.24% with AUC = 0.953 (AUC >0.8); thus, our finding suggested that the most powerful discrimination tool between ruptured aneurysms and UIAs is the aspect ratio. On the other hand, Sato *et al.*[21] concluded that the aspect ratio is the most predictive factor of a ruptured IA in patients with MICAs.[6,10,21,25] However, Neulen *et al.*[15] reported in their recent study that, the PHASES score discriminated better between ruptured aneurysms and UIAs than UIATS. They found that PHASES score estimated a low 5-year rupture risk in a larger proportion of the UIAs (≤0.7% in 62.3%, ≤1.7% in 98.4%) than of the ruptured aneurysms (≤0.7% in 22.5%, ≤1.7% in 82.5%), also in their 40 ruptured aneurysms cases, UIATS provided a recommendation for treatment in 11 (27.5%), and in the 61 UIAs, UIATS recommended treatment in 16 (26.2%). In our series, the PHASES score recommended treatment in 52 of 60 ruptured aneurysms (86.7%) and 6 of 68 UIAs (8.8%), whereas UIATS recommended treatment in 26 of 62 ruptured aneurysms (41.9%) and 35 of 55 UIAs (63.6%). Thus, aspect ratio and PHASES scores are the most predictive tools for treatment recommendation between rupture aneurysms and UIAs in patients with MICA. This might predict the risk of rebleeding and improve the outcomes.

Limitations

One limitation of this study is the relatively small sample size. In addition, this is a monocentric retrospective study. There were only three populations "North American, European (other than Finnish), Japanese, and Finnish" that were considered for the PHASES Score establishment. The lack of many more populations such as the Sub-Saharan Africa, the Maghrebin, and the Arabic should be considered in the interpretation of the results from this study that, nonetheless, is the first step toward attribution of "points" to each of those populations as criteria after knowing the risk rate of IAs rupture in each population. This will most probably give the most accurate sensitivity and specificity of each variable, either scores or ratio in predicting the likelihood of the rupture of IA. A randomized control trial is needed to fix this scarcity of scientific data.

CONCLUSION

Our findings underlined clearly that the aspect ratio and the PHASES score are the most powerful discrimination tools between ruptured aneurysms and the UIAs in patients harboring MICA. This might be a helpful tool to predict the risk of rebleeding as well as the risk of vasospasm which is correlated with a high mortality rate. Future studies like a randomized control trial should be able to allow adding some other population groups to the PHASES Score items.

Submission statement

This manuscript is original and has not been submitted elsewhere.

Disclosures

The authors have nothing to disclose.

Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The author(s) confirms that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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