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ORIGINAL ARTICLE

Evaluation of the risk of rupture of intracranial aneurysms in patients with aneurysmal subarachnoid hemorrhage according to the PHASES score

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Abstract
The PHASES score was developed to determine the risk of rupture of un-ruptured intracranial aneurysms (UIAs). The purposes of the current study were to apply this score on patients with actually ruptured intracranial aneurysms and to analyze the hypothetically prediction of the risk in this particularly patient group. We extracted the data of 100 recently treated patients (23 male, 77 female, mean age 56.4 years, range 17–93 years) with ruptured saccular intracranial aneurysms from our prospectively maintained neurovascular database according to the parameters used in the PHASES score (population, hypertension, age, earlier SAH, size and site of the aneurysm). Descriptive statistical analysis was performed using SPSS for Windows version 18.0 (SPSS Inc., Chicago, Illinois, USA). Ninety-nine percent of the patients were European and 1% Japanese in our series. Pre-existing arterial hypertension was found in 59%. Fifteen percent of the patients were > 75 years. Earlier SAH was found in 1%. The site of the aneurysms were the internal carotid artery (ICA) in 10%, the middle cerebral artery (MCA) in 14%, and arteries of the anterior and posterior circulation (PC) including the posterior communicating artery (PCOM) in 76%. Sixty-six percent of the aneurysms were smaller than 7 mm, 18% ranged between 7 and 9.9 mm, 14% were between 10 and 19.9 mm, and 2% were larger than 20 mm. European population, aneurysm size < 7 mm, and age < 75 years scored with 0 point in the PHASES study occurred most frequently in our series. The distribution of the aneurysm site to the anterior and posterior circulation scored with 4 points occurred most frequently. Considering the 5-year risk of rupture, 70% of our patient collective would have an estimated risk of < 2%. Interestingly, 70% of the patients with aneurysmal SAH had a low risk profile and would have a low risk of rupture according to the PHASES score in our series. This observation underlines the discrepancy of the estimated low risk of rupture for UIAs in young and healthy patients and the obvious fact the majority of the SAH patients are actually young with low risk factors. Parameters beyond the features of the PHASES score are needed to determine the risk of rupture of intracranial aneurysms.

Keywords Subarachnoid hemorrhage · Intracranial aneurysms · Risk of rupture

Introduction

Un-ruptured intracranial aneurysms (UIAs) are diagnosed with an increasing amount due to the more frequent use of neuro-imaging for various reasons. The questions which UIAs are at risk for rupture and should undergo aneurysm repair are subject of an ongoing debate.

The PHASES score was developed to assess a risk profile of the patients in view of the 5-year rupture risk of the aneurysms [6] by analyzing large prospective studies on UIAs. The authors defined the population, the age, and the presence of arterial hypertension as well as the size and the site of the aneurysm and subarachnoid hemorrhage (SAH) in the patient's history as relevant parameters for assessment of the risk of rupture and aim to provide an individualized approach.

Although the PHASES score was developed by reviewing and interpreting prospective data of UIAs, the purposes of the current study were to apply this score on patients with recently ruptured intracranial aneurysms and to evaluate how the PHASES score would predict their risk of rupture.

Materials and methods

For this purpose, we extracted and analyzed the data of the last consecutive 100 treated patients (23 male, 77 female, mean

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age 56.4 years, range 17–93 years) with aneurysmal SAH from our prospectively maintained neurovascular database. Patients with multiple and fusiform aneurysms were excluded from the analysis.

Diagnosis of SAH and the bleeding source were made by cranial CT scanning and digital subtraction angiograms in all cases.

Parameters used in the PHASES score (population, hypertension, age, size of aneurysms, SAH in history, and site of the aneurysms, Table 1) were assembled. The corresponding points for each parameter were summarized and compared to the estimated 5-year rupture risk proposed by the PHASES score (Table 1). Descriptive statistical analysis was performed using SPSS for Windows version 18.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Ninety-nine percent of the patients were European and 1% Japanese in our series. Pre-existing arterial hypertension was found in 59%. Fifteen percent of the patients were older than 75 years. Earlier SAH was found in 1%. The site of the aneurysms was the internal carotid artery (ICA) in 10%, the middle cerebral artery (MCA) in 14% and the anterior cerebral artery (ACA), posterior communicating artery (Pcom), and the posterior circulation (PC) in 76%. Sixty-six percent of the aneurysms were smaller than 7 mm, 18% ranged between 7 and 9.9 mm, 14% were between 10 and 19.9 mm, and 2% were larger than 20 mm (Table 1).

Table 1 Distribution of the parameters of our patient cohort to the PHASES score

Distribution to the PHASES score		
Parameter and points		*n*
Population	0: North American, European	99
	3: Japanese	1
	5: Finnish	0
Hypertension	0: no	59
	1: yes	31
Age	0: < 70 years	85
	1: ≥ 70 years	15
Size of aneurysm	0: < 7.0 mm	66
	3: 7.0–9.9 mm	18
	6: 10.0–19.9 mm	14
	10: > 20 mm	2
Earlier SAH	0: no	99
	1: yes	1
Site of aneurysm	0: ICA	10
	2: MCA	14
	4: ACA/Pcom/PC	76
5-year absolute risk of rupture		
≤ 2 points: 0.4%	3 points: 0.7%	4 points: 0.9%
5 points: 1.3%	6 points: 1.7%	7 points: 2.4%
8 points: 3.2%	9 points: 4.3%	10 points: 5.3%
11 points: 7.2%	≥ 12 points: 17.8%	

European descent, aneurysm size < 7 mm, and age < 75 years scored with 0 point in the PHASES study occurred most frequently in our series. The distribution of the aneurysm site to the ACA, Pcom and the PC scored with 4 points occurred most frequently in our patient collective.

Considering the 5-year risk of rupture, 70% of our patient collective would have an estimated risk of < 2%. Only 11 patients in our series had 10 or more points with a consecutive higher risk of rupture (Fig. 1).

Discussion

The PHASES score was developed to enable a more precise and individualized risk assessment by analyzing several parameters of prospective studies on UIAs [6]. However, the question arises whether this score is applicable in daily routine. Interestingly, by that time, there are online risk calculators based on the data of the PHASES score available, which can be used by family physicians and patients themselves (e.g., www.kockro.com/calculators/calculator-phases/?lang=en, www.surgicalneurology.org/software/uia/ans_calculator_version_24.html). Online calculated low-risk rates could be a huge problem. Affected people could gain a false sense of security.

Regarding the risk factors for rupture of UIAs, the size of the lesions is believed to be an important predictor according to the results of different studies [7, 13, 15]. However, the mismatch between ruptured intracranial aneurysms far below 10 mm and their estimated low risk of rupture is analyzed and pointed out in our previous publication on this topic [10]. The size alone does not seem a significant role, since the majority of the ruptured aneurysms are small sized. However, the size seems to have an elevated risk of rupture compared to other aneurysms in a patient with multiple aneurysms [9].

The results of our study show that the majority of the patients with aneurysmal SAH were young and healthy without a distinct risk profile. Seventy percent of the patients of our cohort would have a 5-year risk of rupture of less than 2% according to the PHASES score.

At this point, the other raised questions are how we would advise a patient with a low-risk profile according to the PHASES score and should we recommend aneurysm repair or go for observation? We believe that this decision is by far more complicated and several other co-factors should be considered [5].

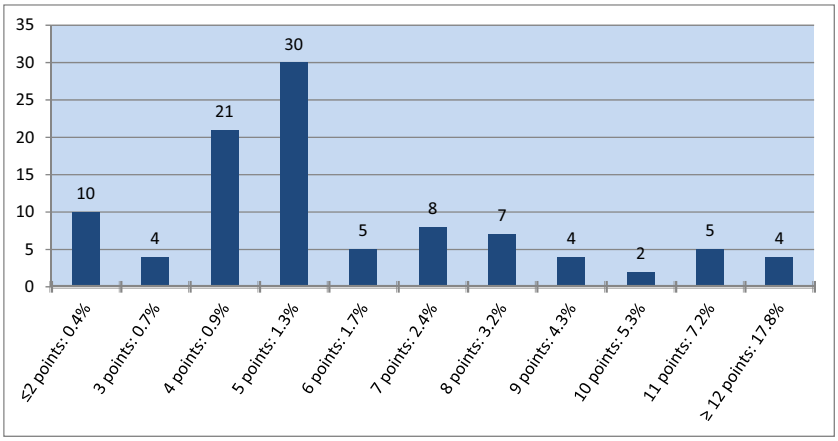

Fig. 1 Illustration of the 5-year rupture risk of our patient collective

It is widely believed that once an UIA is diagnosed, it remains stable for a long period and has a low risk of rupture [7, 13]. A change in size or shape of the aneurysms is believed to be an indicator for instability and exhibits a higher risk of rupture and therefore early treatment is recommended [2, 9].

The theory of intracranial aneurysms in different developmental stages is a very interesting issue pointed out by Jou and Britz [8]. The authors postulate changes in the aneurysm configuration influenced by flow dynamics. Performed MRI with diagnosis of UIA is therefore just a snapshot in time. It remains unclear at which developmental stage the diagnosed UIA actually is. The theory of Sato et al. substantiates this observation. Sato et al. postulate that some aneurysms develop and remain stable for long time with a low risk of rupture. On the other hand, some aneurysms develop and rupture shortly after formation and are small sized and rarely accidentally diagnosed [12]. Since cranial MRI is performed with an increasing frequency, the developmental stage of the lesion still remains unclear.

Considering the anatomical parameters of the aneurysm, only the size and the site of the aneurysms were significant parameters in the PHASES score, whereas other morphological parameters like the inclination angle [11] and the height to width ratio [4] tend to play a role in aneurysm rupture.

However, we believe that the PHASES score is applicable for the human race with primarily proven stable aneurysms to select all these patients at risk out of the defined PHASES parameters. In regions without Fins and Japanese, the remaining parameters are not pioneering and crucial for decision-making.

Since demographic and many morphological parameters are inaccurate for an exact assessment of the risk of rupture for an UIA, other parameters and new imaging modalities are necessary. Inflammation and wall shear stress are two important aspects to understand which aneurysms have a higher risk of rupture [3, 14]. In this context, presentation of the inflammation in the wall of the aneurysms with ultra-high field MRI [1] could be a future perspective, as well as the application of computational flow analysis, which can bring more clarification.

Conclusion

Interestingly, 70% of the patients with aneurysmal SAH had a low-risk profile and would have a low risk of rupture according to the PHASES score in our series. This observation underlines the discrepancy of the estimated low risk of rupture for UIAs in young and healthy patients and the obvious fact the majority of the SAH patients are actually young with low-risk factors. Parameters beyond the features of the PHASES score like wall shear stress, computational flow dynamics, and aneurysm wall inflammation are needed to determine the risk of rupture of intracranial aneurysms more accurately.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval None, retrospective analysis.

Informed consent None.

References

1. Backes D, Hendrikse J, van der Schaaf I, Algra A, Lindgren AE, Verweij BH, Rinkel GJE, Vergouwen MDI (2017) Determinants of gadolinium-enhancement of the aneurysm wall in unruptured intracranial aneurysms. Neurosurgery. https://doi.org/10.1093/neuros/nyx487
2. Brinjikji W, Zhu YQ, Lanzino G, Cloft HJ, Murad MH, Wang Z, Kallmes DF (2016) Risk factors for growth of intracranial aneurysms: a systematic review and meta-analysis. AJNR Am J Neuroradiol 37(4):615–620
3. Cebral JR, Sheridan M, Putman CM (2010) Hemodynamics and bleb formation in intracranial aneurysms. AJNR Am J Neuroradiol 31(2):304–310
4. Elsharkawy A, Lehečka M, Niemelä M, Kivelev J, Billon-Grand R, Lehto H, Kivisaari R, Hernesniemi J (2013) Anatomic risk factors for middle cerebral artery aneurysm rupture: computed tomography angiography study of 1009 consecutive patients. Neurosurgery 73(5):825–837

5. Etminan N, Rinkel GJ (2017) Unruptured intracranial aneurysms: development, rupture and preventive management. Nat Rev Neurol 13(2):126
6. Greving JP, Wermer MJ, Brown RD Jr, Morita A, Juvela S, Yonekura M, Ishibashi T, Torner JC, Nakayama T, Rinkel GJ, Algra A (2014) Development of the PHASES score for prediction of risk of rupture of intracranial aneurysms: a pooled analysis of six prospective cohort studies. Lancet Neurol 13(1):59–66. https://doi.org/10.1016/S1474-4422(13)70263-1
7. International Study of Unruptured Intracranial Aneurysms Investigators (1998) Unruptured intracranial aneurysms—risk of rupture and risks of surgical intervention. N Engl J Med 339(24): 1725–1733
8. Jou L, Britz G (2016) Correlation between aneurysm size and hemodynamics in one individual with multiple small intracranial aneurysms. Cureus 8(7):e683
9. Maslehaty H, Capone C, Frantsev R, Fischer I, Jabbarli R, Cornelius JF, Kamp MA, Cappabianca P, Sure U, Steiger HJ, Petridis AK (2017) Predictive anatomical factors for rupture in middle cerebral artery mirror bifurcation aneurysms. J Neurosurg 25:1–9. https://doi.org/10.3171/2017.2.JNS162705
10. Maslehaty H, Ngando H, Meila D, Brassel F, Scholz M, Petridis AK (2013) Estimated low risk of rupture of small-sized unruptured intracranial aneurysms (UIAs) in relation to intracranial aneurysms in patients with subarachnoid haemorrhage. Acta Neurochir 155(6): 1095–1100; discussion 1100. https://doi.org/10.1007/s00701-013-1688-y
11. Nikolć I, Tasić G, Antunović V, Rakić M, Mihajlović M, Joković M, Stojisavljević M, Kojić Z, Radlović V, Djurović B, Ducić S (2013) Comparative analysis of the animal model and results of the clinical research of the aneurysm inclination angle as the predisposing factor for the occurrence of rupture. Srp Arh Celok Lek 141(3–4):150–154
12. Sato K, Yoshimoto Y (2011) Risk profile of intracranial aneurysms: rupture rate is not constant after formation. Stroke 42(12):3376–3381
13. UCAS Japan Investigators, Morita A, Kirino T, Hashi K, Aoki N, Fukuhara S, Hashimoto N, Nakayama T, Sakai M, Teramoto A, Tominari S, Yoshimoto T (2012) The natural course of unruptured cerebral aneurysms in a Japanese cohort. N Engl J Med 366(26): 2474–2482
14. Vakil P, Ansari SA, Cantrell CG, Eddleman CS, Dehkordi FH, Vranic J, Hurley MC, Batjer HH, Bendok BR, Carroll TJ (2015) Quantifying intracranial aneurysm wall permeability for risk assessment using dynamic contrast-enhanced MRI: a pilot study. AJNR Am J Neuroradiol 36(5):953–959
15. Wiebers DO, Whisnant JP, Huston J III, Meissner I, Brown RD Jr, Piepgras DG, Forbes GS, Thielen K, Nichols D, O'Fallon WM, Peacock J, Jaeger L, Kassell NF, Kongable-Beckman GL, Torner JC, International Study of Unruptured Intracranial Aneurysms Investigators (2003) Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment. Lancet 362(9378):103–110