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A proposed grading system to evaluate the endovascular curability of deep-seated arteriovenous malformations

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ABSTRACT

Background: Aggressive treatment of deep-seated AVMs is paramount because of their high tendency to bleed (or to re-bleed). In the literature concerning endovascular therapy, AVMs of the basal ganglia, the semi-ovale center and the midbrain are always considered as a single entity. In this study, the authors address the anatomical classification of these AVMs and propose a classification that considers factors influencing their endovascular curability.

Methods: From 1995 to 2013, clinical and angiographic data of cerebral AVMs were prospectively collected. We reviewed data from patients treated for a deep-seated AVM with the goal to distinguish factors that influence the curability and the outcome of these AVMs.

Results: 134 patients (mean age: 28 years) were consecutively treated by endovascular techniques. We describe an anatomical classification concerning the exact location of the nidus and distinguish 5 different sub-types (anterior, lateral, medial, posterior and midbrain). Then, we propose a grading system based on statistical analysis of our series to evaluate the curability of a deep AVM. This comprehensive score is calculated with the Spetzler-Martin grade, the location of the nidus, its type, arterial feeders and venous drainage.

Conclusions: Deep-seated AVMs may be classified according to their exact location; we can distinguish 5 different sub-types (anterior, lateral, medial, posterior and midbrain). Each group presented different arterial supplies and venous drainage that influenced treatment possibilities. The comprehensive grading system that we propose in this study must be tested in another deep-seated AVMs population.

1. Introduction

Technical difficulties in the treatment of deep-seated brain arteriovenous malformations (AVMs) grasp the attention of vascular neurosurgeons and interventional neuroradiologists [1]. It is accepted that deep seated AVMs have an higher morbidity and mortality risk than superficial AVMs [2]. Aggressive treatment of these AVMs is paramount because of their high tendency to bleed (or rebleed) [2]. Stereotactic radiosurgery has been proposed as the mainstain therapy for inaccessible small AVMs [3]. In the literature concerning endovascular therapy [4–9], AVMs of the basal ganglia, the semi-ovale center and the midbrain are frequently considered as a single entity. However, these so-called deep-seated AVMs encompass a large number of different anatomical locations; each of these is associated with various risks and endovascular treatment difficulties. The authors reviewed treatment data concerning their series of deep-seated AVMs with the aim to propose a more comprehensive grading system than the Spetzler-Martin to evaluate the endovascular curability of an AVM.

2. Materials and methods

2.1. Demographic data

We have maintained an ongoing prospective database with demographic, clinical and angiographic informations regarding patients with a cerebral arteriovenous malformation. From 1995 to 2013, 1268 cerebral AVMs were treated in our institution. Among them, 134 patients with an AVM involving the deep supratentorial structures or the midbrain were treated by endovascular approach in first intention in our institution. Treatment strategy was discussed with a multidisciplinary team including a neurosurgeon and an interventional neuroradiologist. Demographic data recorded for each patient included age, sex, initial clinical presentation and discovery mode of the AVM. In the case of hemorrhagic presentation, the location of the bleeding was noted (subarachnoid, intraventricular, intraparenchymal). The initial Glasgow coma (GCS) was noted at admission as well as the World Federation of Neurosurgical Societies (WFNS) score.

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2.2. Angiographic characteristics of arterio-venous malformations

All patients underwent a selective six-vessel angiography. Characteristics of the nidus (size, location and type), feeding arteries (number, size, origin) and venous drainage pathways were precisely recorded. The Spetzler-Martin grade [10] was also calculated in every case. AVMs were classified according to their location. The anterior type (A) represented AVMs for which the center of the nidus was anterior to both the anterior limb of the internal capsule and the thalamus. The lateral type (L) included AVMs for which the nidus was lateral to the internal capsule. The medial type (M) consisted of thalamic and intraventricular AVMs limited laterally by the genu and the posterior limb of the internal capsule. The posterior type (P) included AVMs involving the pulvinar and the geniculate bodies. Midbrain AVMs (Mi) were considered as a different entity. Fig. 1 illustrates the 5 different anatomic locations of the nidus.

2.3. Endovascular procedures

Endovascular procedures were performed under general anesthesia and systemic heparinization. After diagnostic digital subtraction angiography (DSA), appropriate working angles for the catheterization of the AVM's arterial supply were recorded. Treatment options included parent artery occlusion by cyanoacrylate synthetic glue (Glubran, *GEM, Viareggio, Italy* or Histoacryl, *Braun, Rubi, Spain*) or embolization of the AVM nidus with Onyx (Medtronic, Irvine, CA, USA). For patients who presented with an AVM associated to a flow-related aneurysm, treatment of the aneurysm was done first. Nidal embolization was done in multiple sessions, until every compartment was occluded. Procedures were withheld if the embolic agent entered a venous outflow or refluxed abundantly into the arterial supply. Subsequent sessions were planned as long as any residual nidus was visible with a catheterizable arterial supply. The endovascular treatment was interrupted when no more arterial supply was endovascularly accessible. An AVM was considered cured once no early venous drainage was visible on any DSA incidence.

2.4. Post-operative follow-up

Follow-up started at the time of diagnosis and finished with the last visit or angiography. Angiographic follow-up after complete exclusion of the AVM consisted of one-year and long term (5 years) DSA. In cases of combined treatment (endovascular therapy followed by radiosurgery), angiographic follow-up was performed at least 3 years after the radiotherapy. We noted the modified Rankin Score (mRS) at the time of each visit and angiography. Poor outcome was defined as a mRS equal to or higher than 3.

2.5. Statistics analysis

The Fisher's exact test was used in the analysis of contingency tables because it was generally accepted for all sample sizes. It was performed using GraphPad Prism version 6.0 for Mac (*GraphPad Software, San Diego California USA*) in order to determine potential factors predictive of good outcome or treatment complications. Univariate linear regressions were performed for the following factors: age, sex, location of the nidus (A, M, L, P or Mi), nidus size and type, Spetzler-Martin grade, number of arterial feeders, presence of MCA or ACA perforators, concomitant anterior and posterior circulation feeders, unique venous drainage. Risk factors with a p-value < 0.05 were considered statistically significant.

3. Results

3.1. Demographic and clinical data of the population

Between 1995 and 2013, 134 consecutive patients with AVMs located in the basal ganglia and/or the midbrain underwent endovascular

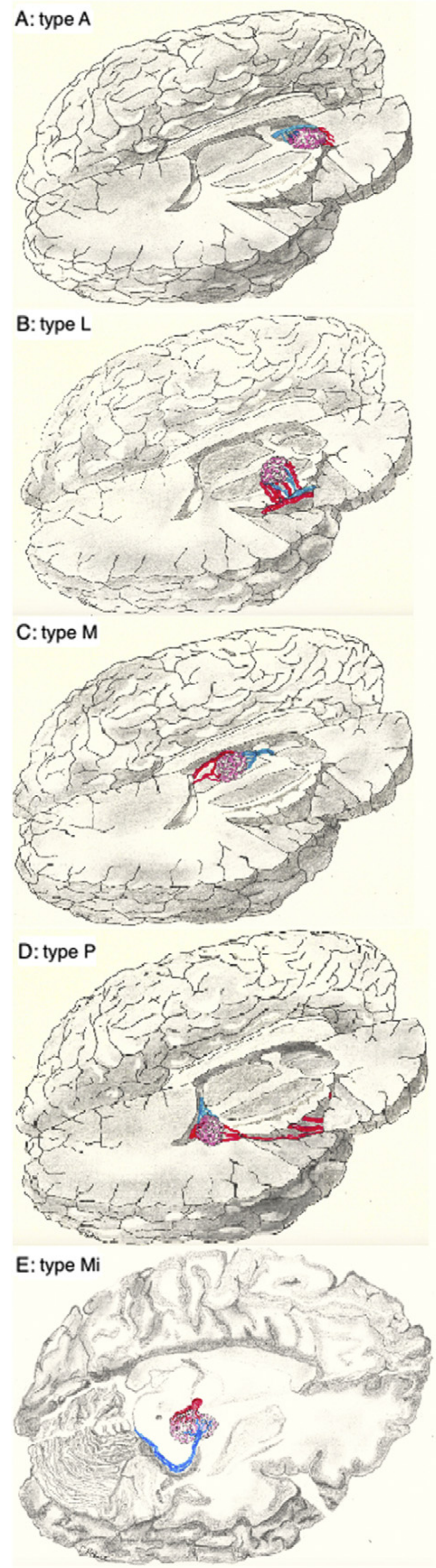

Fig. 1. Artist's illustration representing the 5 types of deep-seated AVMs. A: Anterior type of AVM with feeders from perforating arteries and drained by a anterior caudate vein. B: Lateral type of nidus fed by “en passage” arteries from the insular portion of the middle cerebral artery. C: Medial type of AVM fed by posterior perforating arteries and drained by a thalamostriate vein. D: Posterior type of AVM with a vascularization from the middle cerebral artery and drained by the lateral atrial vein. E: AVM involving the mesencephalon fed by basilar artery perforators and drained in the basal vein.