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# Ruptured cerebral arteriovenous malformations: Outcomes analysis after microsurgery

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ABSTRACT

*Objective:* Our study aimed to evaluate the functional outcome and the risk of postoperative remnant in patients with rAVM after microsurgical treatment.
*Materials and methods:* This is a retrospective of 139 consecutive patients operated for a rAVM between 2002 and 2012 in our institution. The age at diagnosis and the WFNS score were recorded for each patient before treatment. All patients were re-evaluated 3 months after treatment using mRS scale. Conventional angiography was performed in the first 2 postoperative weeks and then a year later to detect any remnant or recurrence.
*Results:* The mean age at diagnosis was 30.8 years (range 4–69 SD: ±5) and 44 patients had an age at diagnosis <18 yo. The mRS score 3 months after treatment was ≤2 in 104 patients (83%). Predictive factors of good functional outcome were age at diagnosis <25 yo, initial WFNS score ≤ 2, SPM grade ≤ 2 and absence of acute hydrocephalus ($p < 0.05$). Complete obliteration was obtained in 123 patients (89.5%) after the first microsurgical treatment. Early postoperative conventional angiography revealed a rAVM remnant in 16 patients (10.5%). Late conventional angiography showed a recurrence in 6 patients (4.5%). All of them were <18 yo. Predictive factors of postoperative rAVM remnant were an initial WFNS score > 2, SPM grade > 2 and preoperative evaluation limited only to CT angiography in emergency situation ($p < 0.05$).
*Conclusion:* Functional outcome after microsurgical treatment was good in 83% of patients with rAVM. Good results were also recorded in 28% of patients with poor initial neurological status and severe intracerebral hemorrhage, which required immediate surgery. In case of remnant, a further treatment should be decided in a true multidisciplinary discussion to protect the patient from any rebleeding.


## 1. Introduction

Ruptured cerebral arteriovenous malformation (rAVM) is frequently managed by the neurosurgeons, particularly in emergency situation. The risk of hemorrhage for unruptured AVM is estimated between 1% and 4% per year according to different authors [11,20]. The history of previous hemorrhage is the main predictive factor of rupture [20]. Some authors reported a higher risk when unique deep venous drainage and/or associated aneurysm are present [11,20]. However, the preliminary findings of ARUBA study support the conservative treatment [27] in patients with unruptured AVM but more delay for evaluation and data analysis is required [3,28]. Concerning rAVM, treatment is mandatory, to preserve vital and functional outcome of patients, and to protect them from a new hemorrhage. Microsurgery remains the main treatment of rAVM, however, endovascular management and radiosurgery should be discussed in some cases as adjuvant therapeutic tools or as unique treatment. For example, previous coiling of associated ruptured aneurysm is sometimes required before microsurgical resection of rAVM [38], or a further treatment by radiosurgery can be performed in case of postoperative rAVM remnant [39]. Nevertheless, microsurgery allows the immediate evacuation of intracerebral hematoma and the resection of the rAVM at the same time. Microsurgical resection also has limitations such as the size of the rAVM or the location in deep or eloquent area. In these cases, the surgical procedure can only evacuate the intracerebral hematoma without attempting to cure the rAVM, which can be treated later using endovascular treatment or radiosurgery.

Our study aimed to evaluate the functional outcome and the risk of postoperative remnant in patients with rAVM after microsurgical treatment.

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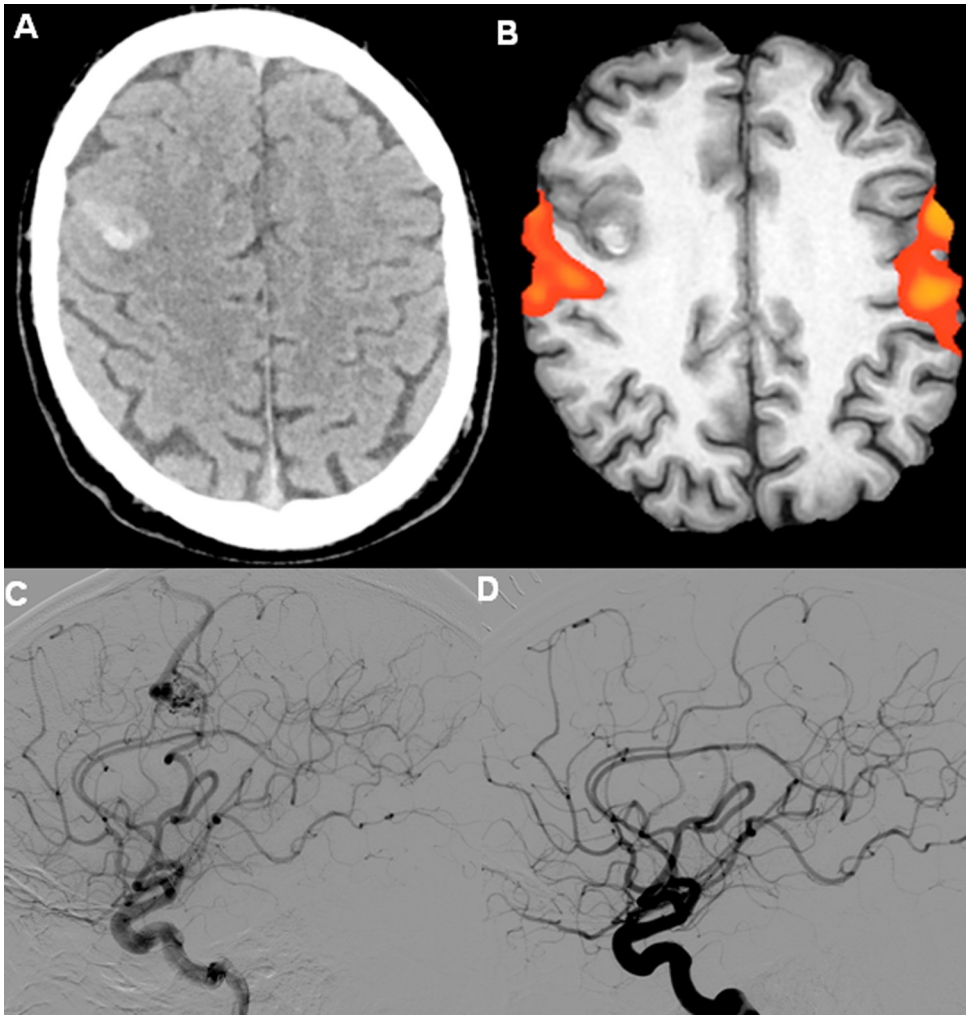


**Fig. 1.** Patient with right precentral rAVM. (A) Preoperative axial CT scan demonstrated a precentral right rAVM. (B) Preoperative brain functional MRI showing motor area behind the rAVM. (C) Preoperative cranial angiography with precentral feeding artery in the rAVM and sagittal sinus venous shunt. (D) Postoperative cranial angiography without remnant.

## 2. Materials and methods

### 2.1. Population

This is retrospective series of 167 consecutive patients treated surgically for a rAVM between 2002 and 2012 at Lille University Hospital. When the first microsurgery deliberately aimed to remove the cerebral hematoma without resecting the rAVM, the patients have not been included in our study ($n = 28$). In these 28 patients, the rAVM was either a large AVM (grade 4 or 5 Spetzler and Martin graduation system (SPM)) or located in eloquent or deep area. Emergency surgical procedure was performed on patients with poor neurological condition (Glasgow scale score < 12) and large intracerebral hematoma ($n = 41$). While, surgery was performed within the 2 first weeks after bleeding for patients in good neurological status (Glasgow scale score ≥ 12) without voluminous hematoma.

### 2.2. Data collection

#### 2.2.1. Clinical data

A clinical examination was performed by a neurosurgeon for all patients in our institution. We recorded the age at diagnosis and the World Federation of Neurologic Surgeons (WFNS) [23] score before treatment to evaluate the initial neurological status of patients. All patients were re-evaluated 3 months after treatment using the modified Rankin Scale score (mRS) [35] to define their functional outcome.

#### 2.2.2. Radiological data

Radiological evaluation was limited to immediate preoperative CT angiography ($n = 41$) when the surgical procedure was performed in emergency. While a complete neuroradiological assessment with conventional angiography and cerebral MRI with neuronavigation protocol was performed ($n = 98$), when the treatment was delayed. Functional MRI has been used in some cases ($n = 5$), when the rAVM was located near eloquent zones like motor area (Fig. 1). AVMs have been classified using Spetzler and Martin graduation system [41]. Conventional cerebral angiography was performed for each patient immediately after surgical treatment to reveal a possible remnant. For patient follow-up, a conventional cerebral angiography was performed 1 year after treatment to detect any recurrence. Recurrence was defined as the presence of a new AVM on conventional angiography 1 year after treatment and the absence of AVM remnant on early postoperative angiography.

### 2.3. Data analysis

Predictive factors of good functional outcome and rAVM remnant have been identified using Chi-squared test and Pearson's