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Overview of patients with vascular pathology and cost analysis of medical care – research market for an entrepreneurial project

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ABSTRACT

Introduction: Brain vascular pathology, aneurysms, arteriovenous malformations (AVMs), cavernomas, dural arteriovenous fistulas (DAVF), venous angiomas and capillary telangiectasia, represents a serious health problem worldwide.

Aim: The aim of this article is to perform an analysis of patients with brain vascular pathology and to analyze costs of health services, a research market for an entrepreneurial project, in order to design guidelines for patients' selection and treatment.

Material and methods: We performed an observational, descriptive study of patients with vascular pathology, from 2018 to 2019.

Results: A total of 153 patients with brain vascular pathology were admitted in our department. Mean age was 49.53 ± 13.997 years. Sex ratio was 0.86. Mean hospital stay was 11.33 ± 13.724 days. Seventy-four patients (48.37%) underwent surgery. Seventy-eight patients (50.98%) had cerebral aneurysms. Complications were seen in 24 patients (30.77%) and vasospasm in 32 cases (41.03%). Thirty-six patients underwent surgery. Outcome was favorable, according to mRS(p=0.001) and Karnofsky score(p=0.006). Thirty-three patients (21.57%) had brain AVMs. Twenty patients underwent surgery. Complications were seen in 4 cases (12.12%). The outcome was favourable, according to mRS(p=0.001) and Karnofsky score (p=0.002). Thirty-nine patients (25.49%) had cavernomas. Surgery was performed in 18 cases. The outcome was favourable, according to Engel Epilepsy Surgery Outcome Scale, mRS (p=0.000) and Karnofsky score (p =0.000). Costs of health services were correlated with longer hospitalization, higher mRS, lower Karnosfsky score, presence of complications and presence of vasospasm.

Conclusions: Proper treatment of brain vascular pathology ensures a favourable outcome. Adequate patients' selection and choosing the best treatment can reduce costs. Surgery is the treatment of choice in ruptured aneurysms, AVMs and cavernomas. Early surgery, with specific treatment of the vascular lesion and removal of intracranial blood ensures a better outcome, with lower medical costs. Prevention of complications, aggressive treatment of vasospasm reduces medical costs.

Keywords
aneurysm, arteriovenous malformation, cavernoma, dural arteriovenous fistula, health care costs

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Introduction

Brain vascular pathology is represented by aneurysms and vascular malformations. Vascular malformations are arteriovenous malformations (AVMs), cavernomas, duralarteriovenousfistulas (DAVF), venous angiomas and capillary telangiectasia.[1]

Brain vascular pathology is a serious health problem world-wide. The incidence of cerebral aneurysms is 0.2-7.9% and the prevalence is 5%.[2] The incidence of brain AVMs is 0.15-3%[3,4] and the prevalence is 0.14%[5,6]. The incidence of cavernomas is 0.15-0.56% and the prevalence is 0.17-0.9%.[7] DAVF, venous angiomas and capillary telangiectasia are rare.

Unfortunately brain vascular pathology occurs in young, active people and more than half of patients present with intracerebral hemorrhage, with significant morbidity and mortality. Peak incidence of aneurysms is 55-60 years[2], AVMs become symptomatic in younger people, mean age is 33 years[5,6] and in cavernomas is 42 years[8]. The most common form of presentation is rupture with subsequent brain hemorrhage. Pattern of hemorrhage depends on type of vascular disease. Aneurysms usually rupture in the subarachnoid space, while AVMs and cavernomas cause intraparenchymatal hematoma. Regardless the type of intracerebral hemorrhage, all are major aggressive factors to the brain and carry important risks of death or development of serious neurological complications. Other forms of presentation are seizures, cranial nerves palsies, motor or sensory deficits, intracranial hyperpressure, ischemia, hydrocephalus, etc.

Surgery is the treatment of choice for aneurysms, AVMs and cavernomas.[9-11]Even though a benign pathology, surgery for brain vascular pathology carries significant risks. For cerebral aneurysms embolization can also be tried.[11] Besides surgery, AVMs also benefit from stereotactic radiosurgery and embolization. DAVF is usually treated through embolization and venous angiomas and capillary telangiectasia do not require treatment.

The aim of this article is to perform an analysis of patients with brain vascular pathology and to analyze the costs of health services, a research market for an entrepreneurial project, in order to design guidelines for patients' selection and treatment.

Material and methods

We performed an observational, descriptive study in which we included patients with vascular pathology admitted in the IVth Department of Neurosurgery, Emergency Clinical Hospital Bagdasar-Arseni, from January 2018 to December 2019. Data were collected in a retrospective manner from January 2018 to August 2019 and prospectively from September 2019 to December 2019. We collected data from hospital medical records and electronic health record Hipocrate. Statistic analysis of data was done using SPSS®.

Results

A total of 153 patients with brain vascular pathology were admitted over a period of time of two years in the IVth Department of Neurosurgery, Emergency Clinical Hospital Bagdasar-Arseni from Bucharest, Romania.Patients with brain vascular pathology represented 2.09% from the total number of admissions in our department.

Vascular brain pathology was represented by aneurysms, AVMs, cavernomas and DAVF. (Figure 1) Mean age of all patients with vascular pathology was 49.53 ± 13.997 years. Sex ratio (M/F) was 0.86. Mean hospital stay was 11.33 ± 13.724 days. A total of 74 patients (48.37%) underwent surgery. The rest of 73 patients either had no indications for surgery, refused surgery or benefit from other nonoperative treatments.

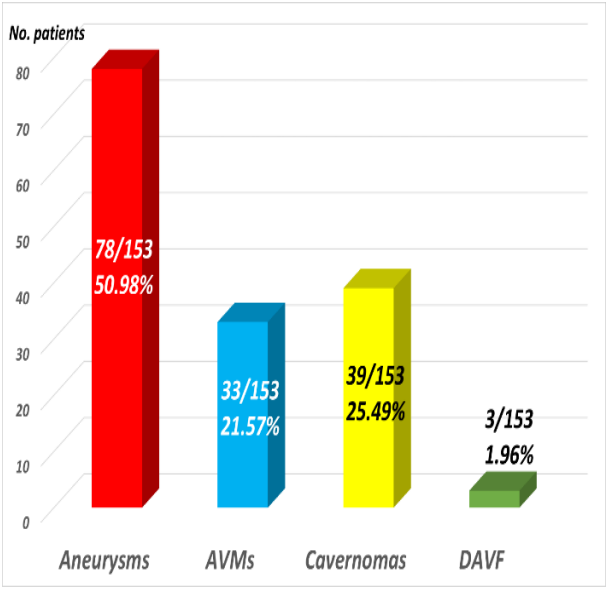

Figure 1. Types of brain vascular pathology.

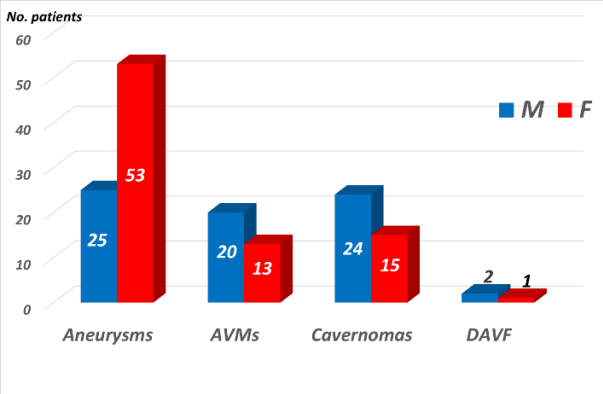

Figure 2. Sex ratio per each type of vascular pathology.

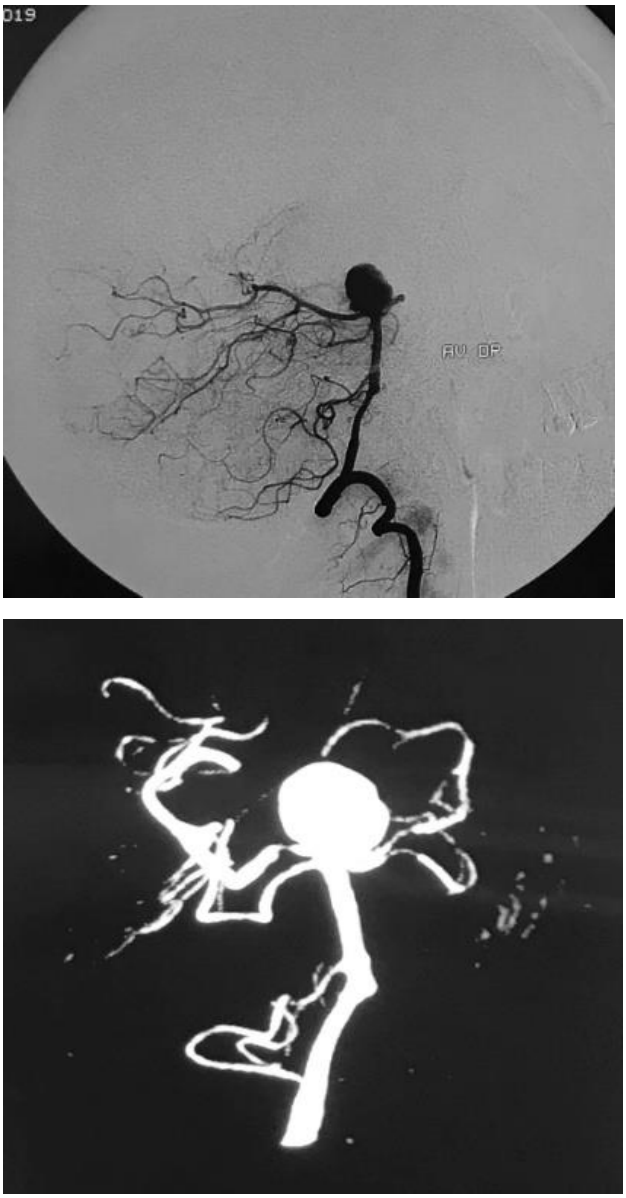

Figure 3. Basilar tip aneurysm.

Aneurysms

Seventy-eight patients (50.98%) were admitted with cerebral aneurysms. Mean age of these patients was 53.73 ± 11.146 years. There were 53 women (67.95%) and 25 men (32.05%). Sixty-two patients (79.49%) had single aneurysm and 16 patients (20.51%) had multiple aneurysms. The latter 16 patients harbor a total number of 35 aneurysms, varying from 2 to 6 lesions per patient. Aneurysms' locations are shown in table 1. Forty-eight (61.54%) had ruptured aneurysms and only 30 people (38.46%) had unruptured ones. From the total number of patients with ruptured aneurysms, according to Hunt and Hess scale, 22 patients were grade I, 4 grade II, 3 grade III, 8 grade IV and 11 grade V. According to Fisher scale, 2 patients had grade I, 17 grade II, 8 grade III and 21 grade IV. Patients with ruptured aneurysms had the following pattern of brain hemorrhage: 45 had subarachnoid hemorrhage, 9 had intraparenchymatal hematoma, 19 intra-ventricular hemorrhage and 2 had subdural hematoma.

Complications were seen in 24 patients (30.77%). Vasospasm, a fearful complication was seen in 32 patients (41.03%). Vasospasmwas more commonly encountered in patients with higher grades on Hunt and Hess and Fisher scales (p=0.000, p=0.000).

Thirty-six patients underwent surgery (34 patients had their aneurysms clipped and in 2 wrapping was done). Outcome was favorable, mRS at discharge were lower than mRSat admission (Z=-3.426, p=0.001) and final Karnofsky scores were higher than initial scores (Z=-2.754, p=0.006).

AVMs

Thirty-three patients (21.57%) were admitted with brain AVMs. Mean age was 40.82± 14.501 years. There were 20 males (60.61%) and 13 females (39.39%). Sixteen patients (48.48%) presented with ruptured AVMs and 13 cases (39.39%) had history of seizures. According to brain hemorrhage pattern 12 patients had intraparenchymatal hematoma, 4 had intraventricular hemorrhage, 3 had subarachnoid hemorrhage and only one had subdural hematoma. Motor deficit was encountered in 11 cases. According to Spetzler-Martin scale, 9 cases (27.27%) were grade I, 8 patients (24.24%) were grade II, 8 (24.24%) grade III, 3 patients (9.09%) were grade IV, 3 cases (9.09%) were grade V and 2 cases (6.06%) had grade VI AVMs. Three patients had flow-related associated

aneurysms. No patient presented cerebral vasospasm.

Twenty patients underwent surgery, 5 cases underwent stereotactic radiosurgery Gamma Knife and 2 patients were embolized. Five patients refused surgery and 2 cases had grade VI Spetzler-Martin AVMs and did not benefit from therapy. Complications were seen in 4 cases (12.12%).

Outcome was favorable, discharge mRSwere lower than admission mRS (Z=-3.332, p=0.001) and finalKarnofsky scores were higher than initial scores (Z=-3.047, p=0.002).

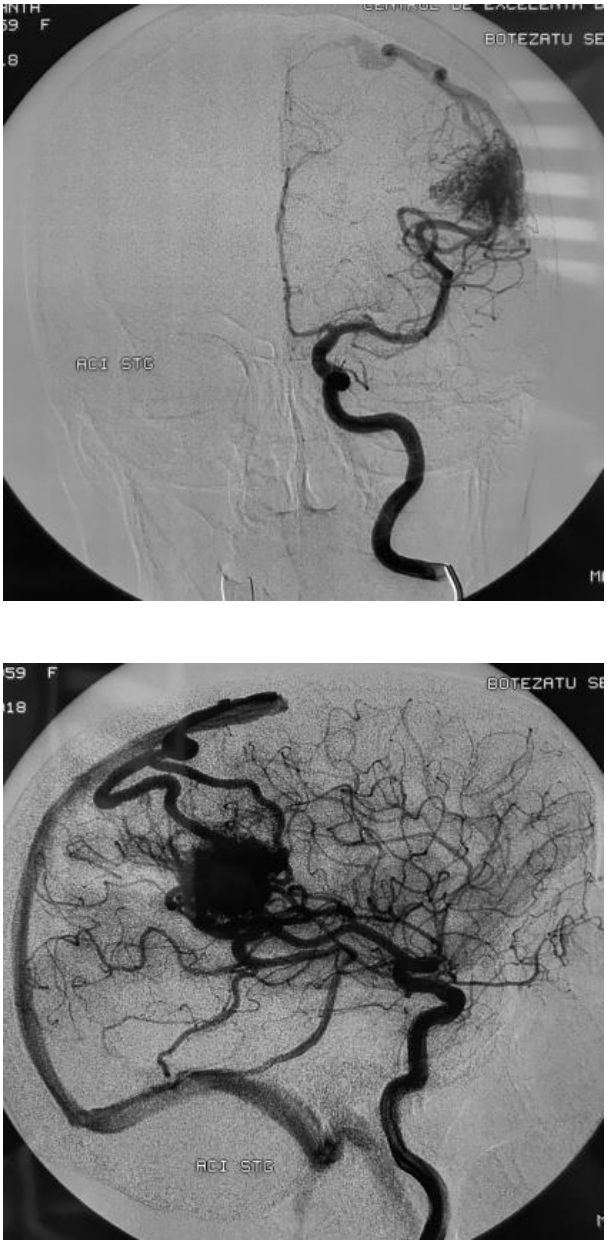

Figure 4. Grade III Spetzler-Martin AVM.

Cavernomas

Thirty-nine patients (25.49%) were admitted with brain cavernomas. Mean age for patients with cerebral cavernomas was 48.28 ± 15.788. Sex ratio (M/F) was 1.6. Thirty-three patients (84.62%) had single cavernomas, but 6 (15.38%) had multiple lesions, the number of cavernomas varying from 3 to 8. Ruptured cavernomas were found in 16 patients. According to the pattern of brain hemorrhage, all 16 patients had intraparenchymatal hematoma, one associated intraventricular hemorrhage and one subdural hematoma. Nine patients had motor deficit and 10 cases were admitted with seizures.Positive diagnosis was done by MRI, T2 echo-gradient and FLAIR. Only 6 patients underwent DSA, and the angiography was negative in all cases. Surgery was performed in 18 cases. Deep cavernomas required intraoperative usage of ultrasound-based neuronavigation system Sonowand®. From the total of 10 patients with epilepsy, 6 underwent surgery, and 3 were free of disabling seizures (Engel IA) postoperative, 2 had worthwhile improvement (Engel IIIB) and one had no worthwhile improvement (Engel IVB). Outcome was favorable, according to mRS (Z=-4.274, p=0.000) and Karnofsky score (Z=-4.283, p =0.000).

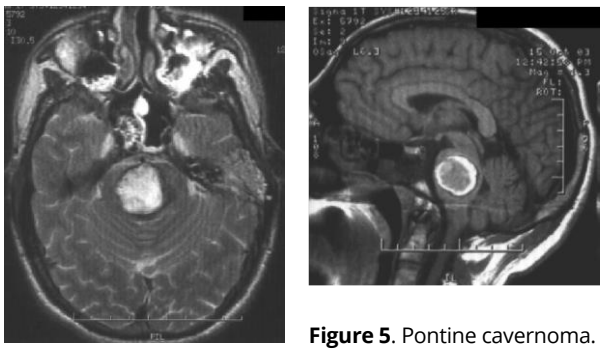

Figure 5. Pontine cavernoma.

Dural AV fistulas

There were only 3 patients (1.96%) with DAVF. Mean age was 52.33 ± 4.933.

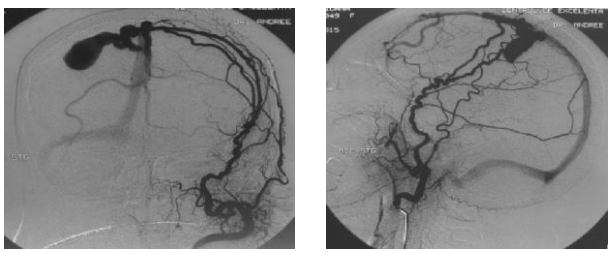

Figure 6. DAVF type IV Merland-Cognard, injected from middle meningeal artery.

Total health care costs accounted for 3215558.4658 lei, and they were composed by 2574452.06 lei hospitalization costs, 14067.4 lei food costs, 15993.085 lei medication costs, 18641.038 lei blood work costs, 105797 lei imaging examinations costs. Hospital staywas positively correlated with hospitalization costs (p=0.000), food costs (p=0.000), medication costs (p=0.000), medical products costs (p=0.000), blood work costs (p=0.000), imaging examinations costs (0=0.002) and total cost of health care(p=0.000). Patients who underwent surgery have higher costs (p=0.000).Patients who presented complications and vasospasm have also higher costs (p=0.000, p=0.000). Higher mRS and lower Karnofsky score at admission were associated with higher costs (p=0.000, p=0.000). Another 575 days for postoperative controls were gathered with additional total costs of 638406.916 lei.

Discussions

Brain vascular pathology was encountered in young, active patients, meanage for the entire group being under 50 years old, with differences for every pathology.

Surgery for vascular lesions is challenging. Only 50% of patients diagnosed with vascular pathology benefit from surgery. This low rate of patients with surgery is caused by several factors. Surgery is indicated when benefits are higher than risks, and we must not forget that we are dealing with high risk surgeries, so there are patients with grade VI AVMs, deep seated unruptured, asymptomatic cavernomas or unruptured ectatic vessels, in which surgery is not required. More, there are patients, or families who refused surgery after they were informed of the possible risks. And there is another group of patients who are not candidate for surgery.

In case of brain aneurysms clipping is the curative treatment.[11,12] Surgical technique depends on location, type and size of aneurysm and angioarchitecture of parental and efferent vessels.[9]One or more clips of different sizes can be used to secure the aneurysm (simple clipping, multiple clipping, tandem clipping, fenestration tubes, clip reconstruction).[9]Other surgical techniques are wrapping and trapping. Surgery for aneurysm must be performed early, to hinder the risk of rebleeding.

Found almost exclusively in cerebral aneurysms, vasospasm is causing important morbidity. Vasospasm occurs between days 3 and 14 after subarachnoid hemorrhage onset, and it is due to presence of blood in the subarachnoid space, which induces arterial vasoconstriction. Vasospasm is associated with higher Fisher and Hunt and Hess grades. Many surgeons do not recommend surgery in this period of time because it increases the risk of vasospasm. Early intensive treatment for vasospasm, such as triple H therapy (hypertension, hypervolemia and hemodilution), intraoperative washing of all subarachnoid spaces from blood clots, calcium channel blockers (nimodipine) or angioplasty may reduce the incidence of vasospasm and its devastating consequences. So, ideally surgery is done early after rupture, before installation of vasospasm and postoperative medical treatment is initiated. But if patient is not admitted in a specialized center before day 3, timing for surgery is debatable. We recommend operating the patient even in the delicate period from day 3 to 14, because clipping the aneurysm allows intraoperative removal of blood clots and postoperative triple H therapy. In our opinion removal of subarachnoid blood, triple H therapy and nimodipine are the most effective treatments. Costs are influences by occurrence of complications, mainly vasospasm, so preventionof vasospasm reduces costs. Vasospasm is not found in patients with AVMs or cavernomas, because they do not bleed in the subarachnoid space, so for this group of patients,specific treatment for vasospasm is not indicated.

Surgery is the treatment of choice in AVMs.[13,14] Complete resection ensures cure of the lesion. Stereotactic radiosurgery causes progressive occlusion of vessels, but unfortunately the effect occurs in time, and until 1-2 years the nidus is still active. Embolization is recommended only as adjuvant before surgery or in grade VI AVMs.[14]The effect of embolization is limited in time, surgery must be performed in the first week after occlusion procedure. After one month the nidus recruits new blood vessels. Principles of surgery for AVMs depend on location, Spetzler-Martin score and angioarchitecture of the lesion. We recommend surgery for all ruptured AVMs and in all lesions located in non-eloquent areas.[15] Conservative treatment and stereotactic radiosurgery can be tried in patients with small, unruptured, located in eloquent areas AVMs.[13] Surgical principles are represented by early coagulation of feeding arteries,

circumferential dissection of the nidus progressing deep and, after complete arterial disconnection of the nidus occlusion of draining veins.[10]We do not perform preoperative embolization of AVMs because it carries the risk of intraprocedural nidus rupture and developing normal perfusion pressure breakthrough. But other authors consider it helpful before surgery.

The angiography was negative in all cases with cavernomas. They are considered to be occult angiographic lesions, because they have very low flow and do not enhance with contrast. We do not recommend angiography in cases suggestive for cavernomas. The imaging of choice is T2 echo-gradient and FLAIR MRI. We recommend surgery in patients with ruptured cavernomas, with intraparenchymatal hematoma, in symptomatic cavernomas and in superficial accessible lesions. Deep, unruptured and asymptomatic cavernomas are kept under surveillance. For brainstem cavernomas, we strongly recommend surgery after the first bleeding, because the second has devastation consequences. In supratentorial cavernomas we recommend resection of hemosiderin ring surrounding the cavernoma. Brain surrounding the lesion impregnated with hemosiderin can be responsible for seizure persistence. So resection of hemosiderin ring ensures good outcome, evaluated through Engel Epilepsy Surgery Outcome Scale. In lesions located in the brainstem we recommend resection of the lesion leaving the hemosiderin ring in place. Infratentorial cavernomas do not produce seizure, and aggressive resection in this delicate area full with eloquent structures induces severe neurological deficits.

We recommend embolization of DAVF.

Total health care costs of patients is composed by hospitalization costs, food costs, medication costs, medical products costs, blood work costs and imaging exams costs.

Longer hospitalization increases costs. Higher costs in the group of patients who underwent surgery compare with patients belonging to the conservative group, even if it is highly significant, it is not relevant because we are a neurosurgical department and we only keep patients for surgery. If a patient has no surgical indication or refuses surgery, we discharge him and he will be treated further in the territorial neurological department. So costs for nonsurgical patients are not adequately evaluated. So, we can conclude that our study illustrates best the surgical group. Food costs are bound to hospitalization cost and comorbidities (e.g. diabetes, renal failure, etc.). Usually blood work costs are not so high, we only take the minimum set before surgery. Vascular pathology does not require special, expensive blood test before surgery. It may increase if patients require repetitive blood analysis (e.g. postoperative anemia, patients in ICU, etc.). Unfortunately, other costs, such as costs with the medical personnel, cost of surgery or costs for days in the ICU, which are included in a bill from the private hospitals, are not included in a state hospital.

Complications also increased costs. So, adequate patients' selection and choosing the best treatment for lowering the rate of possible complications can reduce costs.

Cost analysis is useful as a market research to predict resources needed for patients' investigation and treatment. Such analysis is a useful tool in developing guidelines. The principles of guidelines choosing the best treatment, while optimizing health care services.

A limit of the study is represented by the fact that it precisely illustrates the surgical group, but it is not so reliable in characterizing the conservative group.

Conclusions

Proper treatment of brain vascular pathology ensures a favorable outcome. Adequate patients' selection and choosing the best treatment to lower the rate of possible complications can reduce costs. Surgery is the treatment of choice in ruptured aneurysms, AVMs or cavernomas. Early surgery, with specific treatment of the vascular lesion and removal of intracranial blood ensures a better outcome, with lower medical costs. Prevention of complications, aggressive treatment of vasospasm reduces medical costs. Further analysis is needed to perfect guidelines for treatment of patients with brain vascular pathology.

Table 1. Aneurysms' location.

Aneurysm location	Single aneurysm	Multiple aneurysms	Total no.	Total %
ICA segm C4	3	1	4	4.12
ICA segm C5	4	4	8	8.25
ICA segm C6	10	10	20	20.62
ICA segm C7	2	1	3	3.09
ACoA	18	1	19	19.59
ACA	5	3	8	8.25
MCA	9	11	20	20.62
ACoP	4	3	7	7.22
SCA	1	0	1	1.03
Basilar artery	4	1	5	5.15
PICA	1	0	1	1.03
Vertebral artery	1	0	1	1.03
Total	**62**	**35**	**97**	**100**

Table 2. AVMs' location.

AVM location	Total no.	Total %
F	7	21.21
T	4	12.12
P	4	12.12
O	5	15.15
FP	3	9.09
FT	1	3.03
Sylvian fissure	1	3.03
TP	3	9.09
TPO	2	6.06
Intraventricular	1	3.03
Posterior fossa	2	6.06
Total	**33**	**100**

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Conflict of interests

The authors declare no conflict of interests.

Abbreviations

ACA anterior cerebral artery
ACoA anterior communicating artery
ACoP anterior posterior artery
AVM arteriovenous malformation
DAVF dural arteriovenous fistula
ICA internal carotid artery
MCA middle cerebral artery
mRS modified Rankin score
PICA posteroinferior cerebellar artery
SCA superior cerebellar artery

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