• SPECIAL ARTICLE •

A Proposal for a New Arteriovenous Malformation Grading Scale for Neuroendovascular Procedures and Literature Review

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Background: Traditionally, decisions regarding treatment and outcomes for patients with cerebral arteriovenous malformations (AVM) have made use of the Spetzler-Martin grading scale. The latter has withstood the test of time in clinical practice for AVM patients managed surgically and even when comparing studies involving other modalities of treatment. Recent awareness on the applicability of the grading system for risk assessment and outcome determination in cases of treatment by neuroendovascular means has emerged. We propose a preliminary grading system for neuroendovascular procedures based on a revision of the available literature.

Methods: A literature search using the keywords 'arteriovenous malformation', 'embolization' and 'outcome' was done. Articles studying the factors involved in complications and outcome determination for endovascular cerebral AVM patients were reviewed. These were tabulated and those dealing with anatomical, radiological and hemodynamic descriptions that were noted as significant determinants of risk or clinical outcome were used for development of a preliminary grading system to be used in a follow-up validation study.

Results: A grading system similar to the Spetzler-Martin grading scale was developed using factors deemed in the literature as significant determinants of outcome. The classification includes the number of feeding vessels into the AVM, the eloquence of adjacent areas, and the presence of fistulous components. Follow-up study is underway at our institution to validate our proposal. Yet, significant evidence exists in the literature validating those factors as stand alone determinants of outcome and risk, suggesting that this grading scale may well be applicable to endovascular embolization procedures.

Conclusions: A grading scale similar to the Spetzler-Martin grading system for use in risk assessment and outcome determination in brain AVM patients treated by endovascular techniques seems adequate and clinically feasible. Studies on applicability and validation are underway. [*P R Health Sci J 2010;2:117-120*]

Key words: Arteriovenous malformation, Endovascular, Grade

The Spetzler-Martin (S-M) (1) grading scale has been traditionally used to estimate the risk of surgical intervention in brain arteriovenous malformation (AVM) patients. It is simple, easily applicable and has been validated (1-2) showing its relationship to outcome for surgically treated patients. It has also helped in evaluation of results for other treatment techniques, yet its applicability has recently been questioned (3). Some studies have shown a relationship between outcome and AVM grade for combined treatments (4-7). Others have shown a trend of endovascular complications and grade, suggesting underlying association between the factors included in the classification and outcome (7-9). Others have shown no association whatsoever (3). A scale with improved applicability to endovascular procedures including anatomical, radiological

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and hemodynamic factors encountered during intervention needs to be developed. We propose a preliminary classification using factors already deemed as significant determinants of risk and outcome for endovascular AVM patients. The classification scheme proposed is similar to the S-M grading system since it is very practical in clinical use. This classification will be used in a follow-up retrospective study aimed at validation and modification (if required) of the included parameters.

Methods

A literature search was performed in several medical databases including Medline, the latter showing a total of 750 results using the keywords 'arteriovenous malformation', 'embolization' and 'outcome'. Emphasis was given to those articles dealing with brain AVMs and factors related to endovascular or combined treatment complications and outcome determination. Articles were reviewed and factors like age, sex, clinical presentation, S-M grade, AVM related aneurysms, presence of arteriovenous (AV) fistula, AVM size, number of pedicles, number of embolization procedures, eloquence of adjacent areas, deep venous drainage, en-passage vessels, deep perforator feeders, and liquid embolic agents like n-BCA and Onyx™ were analyzed in terms of relationship to outcome and complication risk. Those factors tested for statistical significance were tabulated. Special attention was given to those factors dealing with radiological anatomy and hemodynamics, since these would be ideal ones for inclusion in a classification scheme for neuroendovascular procedures.

Results

From the search of 750 articles, emphasis was given to those dealing with cerebral AVM embolizations and factors determining outcome and complications. Scarcely over 10 articles were found. We mention those showing trends or statistically significant results for anatomical and hemodynamical AVM descriptors.

Table 1 shows a recompilation of the factors associated with complications and unfavorable outcomes for AVM embolization procedures. In the study by Ledezma et al. (7) a series of 168 patients who underwent combined treatment procedures were analyzed in terms of embolization related complications. Twenty seven complications, combining technical and clinical, were reported. Univariate and multivariate analyses revealed close association between outcome and periprocedural hemorrhage and S-M grades III-V. Statistical results are also shown in Table 1. All other factors including demographics, clinical presentation and several morphological variables like large size, eloquent location, embolization stages and number of vascular pedicles embolized failed to show association with outcome possibly related to the small number of complications. Kim et al. (8) performed a retrospective study of 153 patients evaluated for predictors of complications after embolization. The only factor found with significant correlation to outcome was the number of branches embolized, with more than three related to worse outcome (P=0.017). Only a trend was noted when S-M grade was correlated to outcome (P>0.103). In a prospective study of 233 patients in 545 endovascular procedures Hartmann et al. (3) found a borderline correlation with patient age and number of embolizations and a significant one in the absence of pretreatment neurological deficit. None of the morphological AVM characteristics predicted complications. Gobin et al. (5) found and association between the S-M grade and complication rates in a series of 125 AVMs, most likely due to the association with underlying factors in the classification. Haw et al. (10) using a combined retrospective/prospective database of 306 patients who underwent 513 embolization procedures found close association between complication rate and nidus location near eloquent area, a pure fistula or fistulous component and venous penetration of the glue cast. The statistical results for these parameters along with their references are shown in Table 1.

Table 1. Factors associated with complications and unfavorable outcomes for AVM embolization procedures.

Factor	Reference	Statistical Weight
S-M[a] grade IIII-V	Ledezma et al.	OR 10.6[b], P<0.05[c]
Periprocedural hemorrage	Ledezma et al.	OR 17[b], P<0.0001[c]
Deep venous drainage	Ledezma et al.	P<0.05[c]
Number of branches embolized	Kim et at.	P=0.017[c]
S-M[a] grade	Gobin et al.	N/A[d]
Increasing age	Hartmann et al.	OR 1.04[b], P=0.021 & OR 5.59[c]
Number of embolizations	Hartmann et al.	OR 1.41[b]
Absence of neurological deficit	Hartmann et al.	OR 4.55[b]
Presentation with hemorrhage	Hartmann et al.	P=0.017 & OR 9.59[c]
Small AVM[a] size	Hartmann et al.	P=0.005 & OR 5.30[c]
Presence of deep feeders	Hartmann et al.	P=0.021 & OR 6.60[c]
Location in eloquent area	Haw et al.	P=0.039 & OR 2.48[b]
Presence of AVa fistula	Haw et al.	P=0.0056 & OR 2.29[b]
Venous penetration of glue	Haw et al.	P=0.0012 & OR 2.65[b]

a. S-M=Spetzler-Martin, AVM=arteriovenous malformation, AV=arteriovenous
b. multivariate analysis
c. univariate analysis
d. no test for significance

Discussion

Reports about morbidity and mortality among AVM embolization procedures have been wide (7), morbidity 1.4-51.9% and mortality 0-6%. Certainly this depends on the goal of the endovascular intervention either as curative, adjuvant or palliative, since there is a relationship between aggressiveness of treatment and subsequent risks of intervention (11).

The major complication of AVM embolization is acute hemorrhage. This may be related to post embolization venous occlusion or stagnation (12) or to hemodynamic changes with

reperfusion of chronically underperfused areas and subsequent normal perfusion pressure breakthrough (13). The study by Ledezma et al. (7) shows a correlation between high AVM S-M grade and complications, yet this may be due to a more direct association to any of the included factors in the classification and not necessarily to the grade; in addition no correlation is noted per grade, only to the group of patients with grade III-V AVMs. Worse outcome associated to periprocedural hemorrhage has a logical correlation, and may also be related to the presence of fistulous components or venous occlusion. Kim et al. (8) showed no significant correlation of S-M grade with outcome, only a trend. Yet, this may be due to the low number of complications evaluated, and also variables included in the grading system were not independently analyzed. They also showed a relationship to the number of pedicles embolized. The latter is related to size, and is a parameter more directly associated with endovascular procedures (three or fewer branches embolized had fewer complications). In a study by Hartmann et al. (3) no significant association was noted between S-M grade and complications, even when analyzing each component of the classification. Gobin et al. (5) reported an association between outcome and S-M grade postembolization and preradiosurgical. The results are not evaluated for statistical significance, yet a trend is noted toward higher grade and worse outcome. This is most likely due to implied factors in the classification like eloquence of adjacent areas, larger diameter and increasing number of pedicles with its additive risk per feeder embolization or higher probability of en-passage vessels. Also the presence of deep venous drainage suggests deep arterial feeders which are riskier to embolize. Other authors have suggested that tortuosity of vessels and the presence of associated aneurysms may also increase risks of intervention (3, 9), yet no analysis was found.

There is a definitive correlation between venous drainage impairment and hemorrhagic complications (10, 12, 14-15). Deep venous drainage has been associated with worse outcome when AVMs are surgically approached (1-2). Yet, for endovascular procedures deep venous drainage is not necessarily associated with an increased risk of complications. The hemodynamic behavior of an AVM with every embolization is more important. With each embolization an increased load of pressure is displaced to other AVM weaker areas or to chronically underperfused brain areas that may be prone to normal perfusion pressure breakthrough, causing edema and possibly hemorrhage. This has been demonstrated clinically (10, 15) and theoretically (14). Haw et al. (10) showed a significant correlation between complication rates and nidus location near eloquent areas, a pure AV fistula or fistulous component, and venous penetration of the glue cast. The last two factors may be related, since a fistulous component in an AVM may make it more likely for embolization material to occlude the venous side prematurely increasing the risk for hemorrhage. Also use of other embolic materials like fiber or detachable coils as well as more concentrated liquid embolic agents would be required, the specific combination depending on the experience and preference of the endovascular neurosurgeon.

Taking into account all the factors included in Table 1, we developed a preliminary classification scheme similar to the S-M grading system, since it is simple and practical in clinical use. Factors deemed as significant determinants of outcome and complications during endovascular embolization of an AVM were accounted for and combined in Table 2, along with a point system similar to the S-M grading scale. This classification scheme will be used in a follow-up validation study with possible modification (if required) of the included parameters.

Table 2. Classification scheme for risk assessment during embolization procedures for brain AVMs.

AVMa feature		Points
Number of feeding vessels	<3	1
	3-5	2
	≥6	3
Eloquence of adjacent areas	Non-eloquent	0
	Eloquent	1
Presence of AVa fistula(e)	No AVFa	0
	AVFa	1

a. AVM=arteriovenous malformation, AV=arteriovenous, AVF=arteriovenous fistula or fistulous component

Conclusion

A classification system similar to the S-M grading scale for use in risk assessment and outcome stratification in brain AVM patients treated by endovascular techniques seems adequate and clinically feasible. A preliminary classification scheme seems feasible since there is evidence in the literature dealing with factors that have shown significant correlation with risk and outcome. Retrospective validation study on its applicability and predictive value is underway at our institution.

Resumen

Trasfondo: Tradicionalmente, las decisiones relacionadas al tratamiento y los resultados de pacientes con malformaciones arteriovenosas (MAV) han hecho uso de la clasificación de Spetzler-Martin. Ésta ha resistido la prueba del tiempo en la práctica médica para pacientes de MAV manejados quirúrgicamente, aún cuando se comparan estudios que envuelven otras modalidades de tratamiento. Recientemente, la aplicabilidad de este sistema de gradación para la evaluación de riesgo y determinación de resultados por tratamientos neuroendovasculares ha sido cuestionada. Proponemos un sistema preliminar para procedimientos neuroendovasculares basado en una revisión de la literatura disponible. Métodos: Se

realizó una búsqueda de literatura utilizando las palabras clave 'arteriovenous malformation', 'embolization' y 'outcome'. Los artículos que estudiaban factores envueltos en complicaciones y determinación de resultados para pacientes endovasculares de MAV cerebrales fueron revisados. Esos factores fueron tabulados y aquellos relacionados a descripciones anatómicas, radiológicas y hemodinámicas que eran determinantes significativos de riesgo o resultado clínico se usaron para el desarrollo de un sistema de gradación que se usará subsiguientemente en un estudio de validación. Resultados: Se desarrolló un sistema de gradación similar a la escala de Spetzler-Martin utilizando factores encontrados en la literatura como determinantes significativos de resultados clínicos. La clasificación incluye el número de vasos suplidores de la MAV, la elocuencia de las áreas adyacentes, y la presencia de componentes fistulosos. Estudios subsiguientes se están llevando a cabo para validar esta propuesta. Sin embargo, existe evidencia suficiente en la literatura que valida dichos factores como determinantes significativos de riesgo y resultado, sugiriendo que la escala puede ser usada en procedimientos endovasculares de embolización. Conclusiones: Una escala de gradación similar al sistema de Spetzler-Martin para estimar riesgo y resultado clínico en pacientes de MAV cerebrales tratados por medios endovasculares aparenta ser posible y adecuada para uso clínico. En nuestra institución se están realizando estudios relacionados a su aplicación clínica y validación.

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