Outcome Predictors of Brainstem Cavernous Malformations

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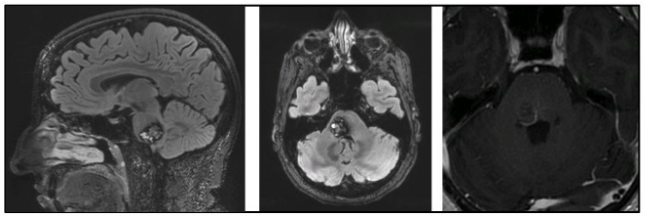
INTRODUCTION: Approximately 8-22% of intracranial cavernomas occur within the brainstem. Surgical resection of brainstem cavernous malformations (BSCMs) is considered the standard of care following hemorrhagic events but predictors of post-surgical outcomes remain poorly described.



RESEARCH HYPOTHESIS: Pre-operative outcome predictors for BSCMs are similar to those used in arteriovenous malformations (AVMs), including Spetzler Martin Grading Scale, Lawton Supplementary Grading Scale

METHODS

- A retrospective chart review was conducted on n=104 consecutative patients from 1997-2012
- Binary logistic regression was perfomed; the outcome variable was dichotomized modified Rankin Scale (mRS) score ≤2 or >2 at last clinical evaluation
- Multivariable logistic regression models were constructed based on the *a prior* hypothesis and univariable logistic regression
- Statistical models were cross validated using 10-fold cross-validation and area under ROC curves

RESULTS

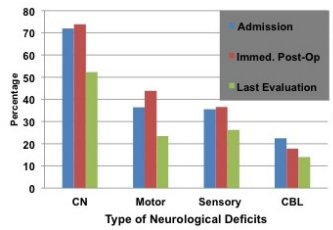
PATIENT DEMOGRAPHICS & BSCM CHARACTERISTICS:

- Mean age (range) = 42.1 years (7-81)
- Gender = 58 females; 46 males
- Maximum lesion diameter, mean in mm (±SE) = 19.3±7.54
- Days since last hemorrhage, mean (range) = 59.2 (1-426)
- One hemorrhagic event = 49 (47.1%)
- DVA present = 48 (46.2%)
- Follow-up time in months, mean (range) = 18.6 (0 - 144)

PATIENT OUTCOMES

- ACCORDING TO mRS SCORES

- mRS score ≤ 2 by last evaluation = 79.8%
- Relative improvement or same mRS score = 89.5%



- Surgical mortality: <1%
- Severe neurological morbidity by last clinical evaluation: 14.4%
- Peri-operative complications: 27%

Table 1: Univariable Logistic Analysis of Preoperative Predictors for Unfavorable Outcomes (mRS >2)

PREOPERATIVE PREDICTOR	OR (95% CI)	p-value
Patient Demographics & Clinical Presentation Predictors		
Age, per year	1.06 (1.02-1.09)	0.002
Female gender	1.37 (0.51-3.66)	0.527
Admission motor deficit present	2.92 (1.10-7.80)	0.032
Admission CN deficit present	2.74 (0.74-10.11)	0.131
DVA present	3.44 (1.15-10.26)	0.027
BSCM Location & Size Predictors		
Lesion located ventrally	1.75 (0.69-4.60)	0.254
Pontine location	0.84 (0.32-2.21)	0.719
Midbrain location	1.30 (0.42-4.10)	0.645
Medullary location	0.99 (0.29-3.33)	0.981
Lesion crossing axial midpoint	2.37 (0.87-6.47)	0.093
Maximal axial diameter, per mm	1.04 (0.98-1.10)	0.233
Hemorrhagic Events & Timing Predictors		
Acute hemorrhage time (<3 wks)	0.52 (0.18-1.48)	0.222
Sub-acute hemorrhage time (>3–8 wks)	0.69 (0.21-2.29)	0.551
Chronic hemorrhage time (>8 wks)	2.41 (0.91-6.38)	0.076
Total hemorrhagic events, per event	1.29 (0.85-1.94)	0.231

Table 2: Multivariable Logistic Regression Models

	FULL MODEL		NESTED MODEL #1	
PREDICTOR	OR (95% CI)	p-value	OR (95% CI)	p-value
Age, per 5 years	1.07 (1.02 – 1.12)	0.001	1.07 (1.03 – 1.11)	0.001
Maximum axial size, per 1 mm	1.09 (0.99 – 1.19)	0.078	1.09 (0.99 – 1.18)	0.080
DVA present	4.15 (1.06 – 16.21)	0.041	4.01 (1.04 – 15.40)	0.043
Acute Hemorrhage Time	0.18 (0.04 – 0.82)	0.027	0.18 (0.04 – 0.82)	0.027
Sub-acute Hemorrhage Time	0.23 (0.05 – 1.45)	0.100	0.24 (0.05 – 1.38)	0.100
Ventral lesion	0.77 (0.22 – 2.73)	0.681	-	-
Lesion crossing axial midpoint	3.60 (0.95 – 13.46)	0.060	3.40 (0.93 – 12.42)	0.075
Follow-up time last surgery, per month	1.02 (1.00 – 1.04)	0.027	1.02 (1.00 – 1.04)	0.030
Area under ROC curve (95% CI)	0.86 (0.79 – 0.94)		0.87 (0.80 – 0.94)	
10-Fold CV Misclassification rate (95% CI)			17.1% (17.0 – 17.2)	

* The baseline reference group includes those presenting with post-hemorrhage time of >8 weeks
* Age centered at median age (40 years)

Proposed BSCM Grading System "GIL" Score [Garcia-Ivan-Lawton]

BSCM Proposed Grading Scale		Point Value
Maximum Axial Size	< 2.5 cm > 2.5 cm	0 1
DVA Present	No Yes	0 1
-	-	-
Age	< 40 >40	0 1
Time since hemorrhage	0-3 weeks >3 weeks	0 1
Lesion crosses axial brainstem midpoint	No Yes	0 1
Total Points Possible		5

AVM Spetzler Martin + Lawton Supplementary Grading Scale		Point Value
Maximum Size	<3cm, 3-6cm, >6cm	1-3
Deep Drainage	No Yes	0 1
Eloquent location	No Yes	0 1
Age	0-20, 20-40, >40	1-3
Unruptured presentation	No Yes	0 1
Diffuseness	No Yes	0 1
Total Points		10

Patient Outcomes Classified by "GIL" Score

	Favorable Outcome (mRS Scores 0-2)		Unfavorable Outcome (mRS Scores 3-6)	
Grade	Frequency of Patients	% Patients with assigned grade	Frequency of Patients	% Patients with assigned grade
0	2	100%	0	0%
I	23	100%	0	0%
II	31	81.6%	7	18.4%
III	21	80.8%	5	19.2%
IV	6	42.9%	8	57.1%
V	0	0%	1	100%
Total	83	59 (79.8%)	21	41(20.2%)

CONCLUSIONS/LIMITATIONS

•Surgical treatment of BSCM can result in serious morbidity but overall outcomes are favorable

•Brainstem cavernous malformations likely have similar predictive factors compared to arteriovenous malformations

•Although the small sample size limits our statistical power and inference, we were able to identify new predictive factors that can aid in assessing patient outcomes following surgical resection of brainstem cavernous malformations

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