



Documentation of Improved Outcomes for Surgical and Endovascular Management of Intracranial Aneurysms Over a 15 Year Interval Using a Comprehensive Grading System

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Introduction

Management of intracranial aneurysms has evolved substantially with marked increase in utilization of endovascular therapy over the last two decades. In this study, we examined changes in treatment trends and outcome for patients with different clinical risk factors.

Methods

We compared two periods of aneurysm management, 1998–2003 (n=1049 patients) and 2007–2013 (n=1500 patients), at a single institution using a previously developed Comprehensive Risk Score to account for known predictors of outcome. 1 point each was assigned for age >50 years, Hunt & Hess grade 4-5, Fisher grade 3-4, and aneurysm size >10 mm. Our outcome of interest was low or moderate disability (Glasgow Outcome Score 4-5) at =6 months post-treatment.

Results

Table 1. Patient and aneurysm characteristics from 1998-2003 and 2007-2013

All patients			
	1998–2003 N=1023	2007–2013 N=1500	P value
Age ≤50 years	437 (42.7%)	473 (31.5%)	<0.0001
Age >50 years	586 (57.3%)	1027 (68.5%)	
Comprehensive risk score 0	268 (26.2%)	318 (21.2%)	<0.0001
Comprehensive risk score 1	434 (42.4%)	798 (53.2%)	
Comprehensive risk score 2	203 (19.8%)	280 (18.7%)	
Comprehensive risk score 3	98 (9.6%)	85 (5.7%)	
Comprehensive risk score 4	20 (2.0%)	19 (1.3%)	
Unruptured			
	1998–2003 N=603	2007–2013 N=1050	P value
Age ≤50 years	256 (42.5%)	315 (30.0%)	<0.0001
Age >50 years	347 (57.5%)	735 (70.0%)	
Comprehensive risk score 0	218 (36.2%)	292 (27.8%)	<0.0001
Comprehensive risk score 1	317 (52.6%)	666 (63.4%)	
Comprehensive risk score 2	78 (12.9%)	92 (8.8%)	
Ruptured			
	1998–2003 N=420	2007–2013 N=450	P value
Age ≤50 years	181 (43.1%)	158 (35.1%)	0.0191
Age >50 years	239 (56.9%)	292 (64.9%)	
Hunt & Hess 1-3	290 (69.0%)	333 (74.0%)	0.123
Hunt & Hess 4-5	130 (31.0%)	117 (26.0%)	
Fisher 0-2	121 (28.8%)	74 (16.4%)	<0.0001
Fisher 3-4	299 (71.2%)	375 (83.3%)	
Comprehensive risk score 0-2	303 (72.1%)	346 (76.9%)	0.126
Comprehensive risk score 3-4	117 (27.9%)	104 (23.1%)	

Table 2. Choice of treatment modality by age, Hunt & Hess grade, Fisher grade, and Comprehensive Risk Score comparing 1998-2003 and 2007-2013

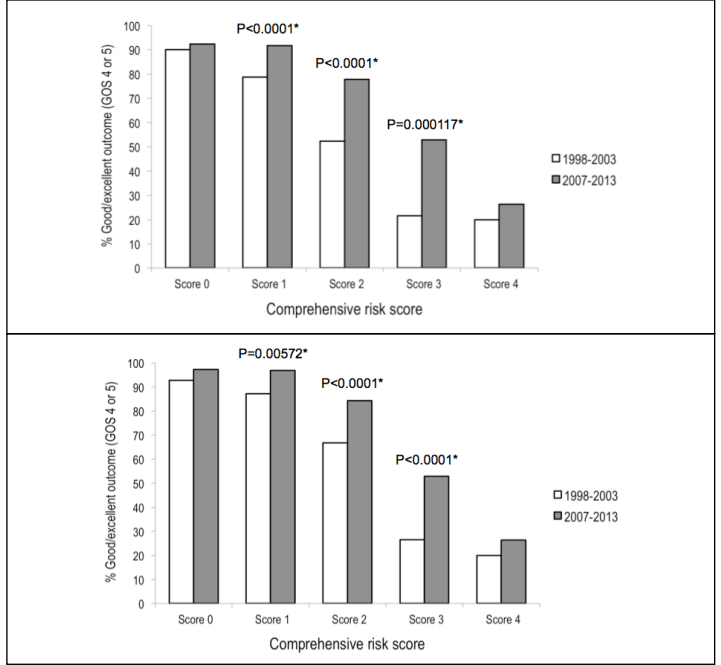
	1998–2003		2007–2013		P
	Surgery	Endovascular	Surgery	Endovascular	
All patients	833 (81.4%)	190 (18.6%)	1018 (67.9%)	482 (32.1%)	<0.0001
Age ≤50 years	361 (82.6%)	76 (17.4%)	359 (75.9%)	114 (24.1%)	0.0161
Age >50 years	472 (80.5%)	114 (19.5%)	659 (64.2%)	368 (35.8%)	<0.0001
Comprehensive risk score 0	243 (90.7%)	25 (9.3%)	243 (76.4%)	75 (23.6%)	<0.0001
Comprehensive risk score 1	363 (83.6%)	71 (16.4%)	552 (69.2%)	246 (30.8%)	<0.0001
Comprehensive risk score 2	154 (75.9%)	49 (24.1%)	165 (58.9%)	115 (41.1%)	0.000156
Comprehensive risk score 3	61 (62.2%)	37 (37.8%)	49 (57.6%)	36 (42.4%)	0.548
Comprehensive risk score 4	12 (60.0%)	8 (40.0%)	9 (47.4%)	10 (52.6%)	0.527
Unruptured	514 (85.2%)	89 (14.8%)	727 (69.2%)	323 (30.8%)	<0.0001
Age ≤50 years	227 (88.7%)	29 (11.3%)	234 (74.3%)	81 (25.7%)	<0.0001
Age >50 years	287 (82.7%)	60 (17.3%)	493 (67.1%)	242 (32.9%)	<0.0001
Comprehensive risk score 0	200 (91.7%)	18 (8.3%)	223 (76.4%)	69 (23.6%)	<0.0001
Comprehensive risk score 1	259 (84.4%)	48 (15.6%)	456 (68.5%)	210 (31.5%)	<0.0001
Comprehensive risk score 2	55 (70.5%)	23 (29.5%)	48 (52.2%)	44 (47.8%)	0.0226
Ruptured	319 (76.0%)	101 (24.0%)	291 (64.7%)	159 (35.3%)	0.000371
Age ≤50 years	134 (74.0%)	47 (26.0%)	125 (79.1%)	33 (20.9%)	0.332
Age >50 years	185 (77.4%)	54 (22.6%)	166 (56.8%)	126 (43.2%)	<0.0001
Hunt & Hess 1–3	237 (81.7%)	53 (18.3%)	214 (64.3%)	119 (35.7%)	<0.0001
Hunt & Hess 4–5	82 (63.1%)	48 (36.9%)	77 (65.8%)	40 (34.2%)	0.753
Fisher 1–2	101 (83.5%)	20 (16.5%)	47 (62.7%)	28 (37.3%)	0.0018
Fisher 3–4	218 (72.9%)	81 (27.1%)	244 (65.1%)	131 (34.9%)	0.0362
Comprehensive risk score 0-2	246 (81.2%)	57 (18.8%)	233 (67.5%)	113 (32.7%)	<0.0001
Comprehensive risk score 3-4	73 (62.4%)	44 (37.6%)	58 (55.8%)	46 (44.2%)	0.388

Table 3. Proportion of patients with low or moderate disability (GOS 4 or 5) from 1998-2003 and 2007-2013

	Endovascular 1998-2003	Endovascular 2007-2013	P	Total 1998-2003	Total 2007-2013	P
All patients						
Overall outcome	126/190 (66.3%)	439/482 (91.1%)	<0.0001	805/1023 (78.7%)	1368/1500 (91.2%)	<0.0001
Age ≤50 years	55/76 (72.4%)	107/114 (93.9%)	<0.0001	371/437 (84.9%)	440/473 (93.0%)	0.00013
Age >50 years	71/114 (62.3%)	332/368 (90.2%)	<0.0001	434/586 (74.1%)	928/1027 (90.4%)	<0.0001
Risk score 0	24/25 (96.0%)	74/75 (98.7%)	0.439	258/268 (96.3%)	309/318 (97.2%)	0.642
Risk score 1	58/71 (81.7%)	239/245 (97.2%)	<0.0001	386/434 (88.9%)	773/798 (96.9%)	<0.0001
Risk score 2	32/49 (65.3%)	99/115 (86.1%)	0.00492	135/203 (66.5%)	236/280 (84.3%)	<0.0001
Risk score 3	7/37 (18.9%)	23/36 (63.9%)	0.000124	22/98 (22.4%)	45/89 (50.6%)	0.000117
Risk score 4	1/8 (12.5%)	4/10 (40.0%)	0.314	4/20 (20.0%)	5/19 (26.3%)	0.716
Unruptured						
Overall outcome	63/69 (91.3%)	317/323 (98.1%)	0.0384	569/603 (94.4%)	1026/1050 (97.7%)	0.000610
Age ≤50 years	28/29 (96.6%)	79/81 (97.5%)	1	248/256 (96.9%)	307/315 (97.5%)	0.868
Age >50 years	55/60 (91.7%)	238/242 (98.3%)	0.0214	321/347 (92.5%)	719/735 (97.8%)	<0.0001
Risk score 0	18/18 (100%)	68/69 (98.6%)	1	213/218 (97.7%)	265/282 (97.6%)	1
Risk score 1	43/48 (89.6%)	207/210 (98.6%)	0.00544	286/307 (93.2%)	652/666 (97.9%)	0.00046
Risk score 2	22/23 (95.7%)	42/44 (95.5%)	1	70/78 (89.7%)	89/92 (96.7%)	0.125
Ruptured						
Overall outcome	43/101 (42.6%)	122/159 (76.7%)	<0.0001	236/420 (56.2%)	342/450 (76.0%)	<0.0001
Age ≤50 years	27/47 (57.4%)	28/33 (84.8%)	0.0164	123/181 (68.0%)	133/158 (84.2%)	0.000843
Age >50 years	16/54 (29.6%)	94/126 (74.6%)	<0.0001	113/239 (47.3%)	209/292 (71.6%)	<0.0001
Hunt-Hess 1-3	34/53 (64.2%)	105/119 (88.2%)	0.000476	206/290 (71.0%)	289/333 (86.8%)	<0.0001
Hunt-Hess 4-5	9/48 (18.8%)	17/40 (42.5%)	0.028	30/130 (23.1%)	53/117 (45.3%)	0.000375
Fisher 1-2	12/20 (60.0%)	23/28 (82.1%)	0.17	103/121 (85.1%)	68/75 (90.7%)	0.363
Fisher 3-4	31/81 (38.3%)	99/131 (75.6%)	<0.0001	133/299 (44.5%)	274/375 (73.1%)	<0.0001
Risk score 0	6/7 (85.7%)	6/8 (75.0%)	1	4/50 (8.0%)	24/26 (92.3%)	1
Risk score 1	15/23 (65.2%)	32/36 (88.9%)	0.0613	100/127 (78.7%)	121/132 (91.7%)	0.00672
Risk score 2	15/27 (55.6%)	57/71 (80.3%)	0.0264	66/126 (52.4%)	147/189 (77.8%)	<0.0001
Risk score 3	6/36 (16.7%)	23/36 (63.9%)	0.000121	21/87 (24.1%)	45/85 (52.9%)	<0.0001
Risk score 4	1/8 (12.5%)	4/10 (40.0%)	0.444	4/20 (20.0%)	5/19 (26.3%)	0.93

Outcomes are reported as number of patients with low or moderate disability/total number of patients in each risk category (proportion of patients with low or moderate disability).

Figure 1. Outcomes for all patients (top) and ruptured aneurysms (bottom) stratified by our Comprehensive Risk Score



Conclusions

We report significantly improved outcomes for surgical, endovascular, and overall treatment of unruptured and ruptured intracranial aneurysms. For ruptured aneurysms, there was significant improvement in outcome for multiple patient subgroups including older patients, patients with poor Hunt & Hess grade, and patients with 2 or 3 risk factors for poor outcome.

Improved outcomes likely reflect increased utilization of endovascular strategies, aggressive management of complications such as cerebral vasospasm, improved NICU care, and judicious selection of aneurysms for surgical or endovascular therapy.

Our findings endorse the prevailing preference for endovascular therapy for treatment of both unruptured and ruptured aneurysms in older patients as well as increased elective treatment of unruptured aneurysms.