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Supplemental material

Basal ganglia cavernous malformations: case series and systematic review of surgical management and long-term outcomes

Li et al.

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Supplementary Table 1: Baseline Characteristics

		Patient Characteristics				Cavernous Malformation Characteristics					
Study	Location	#pts	Male	Female	Mean age	Avg size (cm)	L side	R side	Caudate	Putamen	Gpi
Bicknell et al., 1978 ¹	New Mexico	1	1	0	56	3.5	0	1	1	0	0
Yamasaki et al., 1986 ²	Kyoto	2	1	1	38.5	4	1	1	1	1	1
Lobato et al., 1988 ³	Madrid	1	1	0	47	N/A	N/A	N/A	N/A	N/A	N/A
Bertalanffy et al., 1991 ⁴	Freiburg	3	1	2	28.3	3.67	2	1	0	N/A	N/A
Lorenzana et al., 1992 ⁵	Badajoz	1	0	1	19	3	1	0	1	1	1
Tomlinson et al., 1994 ⁶	Mayo Clinic	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Carpay et al., 1994 ⁷	The Hague	1	1	0	11	N/A	1	0	1	0	0
Houtteville, 1995 ⁸	Normandie	2	N/A	N/A	N/A	N/A	N/A	N/A	2	0	0
Pozzati et al., 1996 ⁹	Bologna	2	1	1	17.5	N/A	N/A	N/A	2	0	0
Di Rocco et al., 1996 ¹⁰	Rome	2	N/A	N/A	N/A	N/A	1	1	N/A	N/A	N/A
Heffez, 1997 ¹¹	Chicago	4	1	3	37	N/A	3	1	0	N/A	N/A
Zamorano et al., 1997 ¹²	Wayne State	1	1	0	15	N/A	N/A	N/A	N/A	N/A	N/A
Hashimoto et al., 1997 ¹³	Nara Medical	1	1	0	0	N/A	0	1	1	0	0
Woydt et al., 1999 ¹⁴	Wurzburg	1	1	0	12	N/A	0	1	0	1	1
Stacey et al., 2000 ¹⁵	London	1	0	1	18	N/A	1	0	1	1	1
Duffau, 2000 ¹⁶	Paris	1	1	0	33	N/A	0	1	0	1	1
Attar et al., 2001 ¹⁷	Ankara	1	1	0	6	N/A	1	0	0	N/A	N/A
Thobois et al., 2004 ¹⁸	Lyon	1	1	0	24	4	1	0	1	1	0
Winkler et al., 2006 ¹⁹	Leipzig	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Alves de Sousa, 2007 ²⁰	Brazil	3	N/A	N/A	N/A	N/A	N/A	N/A	3	0	0
van Lindert et al., 2007 ²¹	Radboud	1	1	0	3	6.5	1	0	1	1	1
Kon et al., 2007 ²²	Niigata	1	1	0	0.5	5	1	0	0	1	1
Leal et al., 2010 ²³	Caen	4	1	3	38.8	N/A	2	2	1	4	4
Chang et al., 2011 ²⁴	UCSF	27	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wostrack et al., 2012 ²⁵	Munich	4	3	0	47.25	N/A	N/A	N/A	N/A	N/A	N/A
Rodriguez-Hernandez & Lawton, 2013 ²⁶	UCSF	1	1	0	66	3	1	0	1	0	0

Abla et al., 2013 ²⁷	Barrow	1	1	0	29	N/A	0	1	0	1	1
Gross et al., 2013 ²⁸	Boston Children	6	3	3	9.5	2.55	N/A	N/A	3	3	0
Pasqualin et al., 2014 ²⁹	Verona	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ren et al., 2019 ³⁰	Beijing	1	N/A	N/A	N/A	N/A	1	0	1	0	0
Norat et al., 2019 ³¹	Virginia	1	0	1	25	N/A	0	1	0	1	0
Current Study	Stanford	44	24	20	38.5	2	16	26	9	26	23
TOTAL		134	48	36	0.5 - 66	2 - 6.5	34	38	30	43	35

Abbreviations: GP - Globus Pallidus

Supplementary Table 2: Presenting Signs/Symptoms

Study	Hemorrhage	Hydrocephalus	Headache	Seizure	Motor deficit	Tremor/Chorief form movements	Sensation deficit
Bicknell et al., 1978 ¹	0	0	0	0	1	1	0
Yamasaki et al., 1986 ²	1	0	1	0	1	0	1
Lobato et al., 1988 ³	1	0	1	0	1	0	0
Bertalanffy et al., 1991 ⁴	N/A	0	0	0	2	0	1
Lorenzana et al., 1992 ⁵	0	0	0	0	1	0	0
Tomlinson et al., 1994 ⁶	N/A	0	N/A	N/A	N/A	N/A	N/A
Carpay et al., 1994 ⁷	1	0	0	0	0	1	0
Houtteville, 1995 ⁸	2	0	0	0	0	0	0
Pozzati et al., 1996 ⁹	1	0	0	1	1	0	0
Di Rocco et al., 1996 ¹⁰	2	0	0	1	0	0	0
Heffez, 1997 ¹¹	3	0	0	0	4	0	3
Zamorano et al., 1997 ¹²	0	0	0	1	0	0	0
Hashimoto et al., 1997 ¹³	1	1	0	0	0	0	0
Woydt et al., 1999 ¹⁴	1	0	0	0	1	0	0
Stacey et al., 2000 ¹⁵	1	0	0	0	1	0	0
Duffau, 2000 ¹⁶	1	0	0	0	1	0	0
Attar et al., 2001 ¹⁷	1	0	0	0	1	0	0
Thobois et al., 2004 ¹⁸	1	0	1	0	1	0	0
Winkler et al., 2006 ¹⁹	N/A	0	N/A	N/A	N/A	N/A	N/A
Alves de Sousa, 2007 ²⁰	N/A	0	N/A	N/A	N/A	N/A	N/A
van Lindert et al., 2007 ²¹	0	0	0	1	1	0	0
Kon et al., 2007 ²²	0	0	0	0	1	0	0
Leal et al., 2010 ²³	2	0	3	2	3	1	0
Chang et al., 2011 ²⁴	N/A	0	9	4	14	3	0
Wostrack et al., 2012 ²⁵	N/A	0	1	1	2	0	3
Rodriguez-Hernandez & Lawton, 2013 ²⁶	0	0	0	0	0	1	0
Abla et al., 2013 ²⁷	1	0	0	0	1	0	0

Gross et al., 2013 ²⁸	6	??	0	1	0	2	0
Pasqualin et al., 2014 ²⁹	0	0	0	5	0	0	0
Ren et al., 2019 ³⁰	N/A	0	0	0	1	0	1
Norat et al., 2019 ³¹	0	0	0	0	1	0	1
Current Study	42	3	28	14	16	0	8
TOTAL	68	4	44	31	56	9	18

Supplementary Table 3: Surgical Approaches

Study	Transsylvian	Transcortical	Transcollosal	Subfrontal
Bicknell et al., 1978 ¹	N/A	N/A	N/A	N/A
Yamasaki et al., 1986 ²	N/A	N/A	N/A	N/A
Lobato et al., 1988 ³	N/A	N/A	N/A	N/A
Bertalanffy et al., 1991 ⁴	3	0	0	0
Lorenzana et al., 1992 ⁵	0	0	0	1
Tomlinson et al., 1994 ⁶	N/A	N/A	N/A	N/A
Carpay et al., 1994 ⁷	0	1	0	0
Houtteville, 1995 ⁸	1	1	0	0
Pozzati et al., 1996 ⁹	N/A	N/A	N/A	N/A
Di Rocco et al., 1996 ¹⁰	0	2	0	0
Heffez, 1997 ¹¹	4	0	0	0
Zamorano et al., 1997 ¹²	N/A	N/A	N/A	N/A
Hashimoto et al., 1997 ¹³	0	1	0	0
Woydt et al., 1999 ¹⁴	N/A	N/A	N/A	N/A
Stacey et al., 2000 ¹⁵	0	1	0	0
Duffau, 2000 ¹⁶	1	0	0	0
Attar et al., 2001 ¹⁷	1	0	0	0
Thobois et al., 2004 ¹⁸	0	1	0	0
Winkler et al., 2006 ¹⁹	N/A	N/A	N/A	N/A
Alves de Sousa, 2007 ²⁰	N/A	N/A	N/A	N/A
van Lindert et al., 2007 ²¹	1*	1*	0	0
Kon et al., 2007 ²²	1	0	0	0
Leal et al., 2010 ²³	4	0	0	0
Chang et al., 2011 ²⁴	N/A	N/A	N/A	N/A
Wostrack et al., 2012 ²⁵	4	0	0	0
Rodriguez-Hernandez & Lawton, 2013 ²⁶	0	0	1	0
Abla et al., 2013 ²⁷	0	0	1	0

Gross et al., 2013 ²⁸	3	2	0	1
Pasqualin et al., 2014 ²⁹	10	0	0	0
Ren et al., 2019 ³⁰	N/A	N/A	N/A	N/A
Norat et al., 2019 ³¹	1	0	0	0
Current Study	24	10	3	2
TOTAL	58	20	5	4

*2-staged surgery

Supplementary Table 4: Outcomes

Study	Imaging Outcome	Functional Outcome		
	Complete Resection	Improved/same	Worse	Mortalities
Bicknell et al., 1978 ¹	1	1	0	0
Yamasaki et al., 1986 ²	1	2	0	0
Lobato et al., 1988 ³	1	1	0	0
Bertalanffy et al., 1991 ⁴	N/A	0	3	0
Lorenzana et al., 1992 ⁵	1	1	0	0
Tomlinson et al., 1994 ⁶	N/A	3	0	0
Carpay et al., 1994 ⁷	1	1	0	0
Houtteville, 1995 ⁸	2	2	0	0
Pozzati et al., 1996 ⁹	2	2	0	0
Di Rocco et al., 1996 ¹⁰	2	2	0	0
Heffez, 1997 ¹¹	N/A	4	0	0
Zamorano et al., 1997 ¹²	1	1	0	0
Hashimoto et al., 1997 ¹³	1	1	0	0
Woydt et al., 1999 ¹⁴	N/A	1	0	0
Stacey et al., 2000 ¹⁵	1	1	0	0
Duffau, 2000 ¹⁶	1	1	0	0
Attar et al., 2001 ¹⁷	N/A	1	0	0
Thobois et al., 2004 ¹⁸	1	1	0	0
Winkler et al., 2006 ¹⁹	N/A	1	0	0
Alves de Sousa, 2007 ²⁰	N/A	3	0	0
van Lindert et al., 2007 ²¹	0	1	0	0
Kon et al., 2007 ²²	0	1	0	0
Leal et al., 2010 ²³	3	4	0	0
Chang et al., 2011 ²⁴	27	24	3	0
Wostrack et al., 2012 ²⁵	4	4	0	0
Rodriguez-Hernandez & Lawton, 2013 ²⁶	1	1	0	0

Abla et al., 2013 ²⁷	1	1	0	0
Gross et al., 2013 ²⁸	5	6	0	0
Pasqualin et al., 2014 ²⁹	N/A	8	2	0
Ren et al., 2019 ³⁰	N/A	1	0	0
Norat et al., 2019 ³¹	1	1	0	0
Current Study	44	40	4	0
TOTAL	102	122	12	0

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Supplementary Table Legends:

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Supplementary Table 2: Presenting Signs/Symptoms

Supplementary Table 3: Surgical Approaches

Supplementary Table 4: Outcomes