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Original Article

Bibliometric analysis of the top 100 most cited articles on the basilar artery

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ABSTRACT

Background: The basilar artery (BA) is one of the most critical vessels that supply blood to the brain stem, cerebellum, and parts of the cerebral hemispheres. Many studies on the BA from neurobiological, clinical, and experimental perspectives exist. This bibliometric study was aimed at identifying the most-cited articles related to the BA in different disciplines.

Methods: A title-specific search was carried out using the Scopus database, and the top 100 most-cited articles were collected and analyzed. Article- and cytometric-based parameters were established for the literature review.

Results: The top 100 articles have an accumulative citation count of 13,595, with an average of 135.95 citations per paper. The publication dates range from 1946 to 2015, with the most productive years being those in the 1990s. Experimental studies are the most frequent category, followed by endovascular ones. The top-cited article has received a total of 435 citations, with 18.12 citations per year. The United States of America has contributed the most to the top 100 cited articles. The lead research institution was the University of Bern, and the most contributing journal was the *Journal of Neurosurgery*.

Conclusion: A bibliometric analysis of BA researches revealed landmark papers and trends over the years, such as on the introduction of endovascular management in basilar aneurysm and occlusion. The highly cited articles in multi-disciplinary areas related to the BA may help develop future novel ideas for research in the laboratory and translational fields.

Keywords: Basilar artery aneurysm, Basilar artery, Bibliometric, Citation analysis

INTRODUCTION

The basilar artery (BA) is formed by the joining of two vertebral arteries at the pontomedullary junction. It courses close to the brainstem and terminates at the pontomesencephalic sulcus (in almost 80% people). It divides into an inferior branch (superior cerebellar artery) and a superior branch (posterior cerebral artery).[20,22] In addition to small perforating arteries, multiple vessels connecting to the brainstem originate from the BA trunk.[20,22]

The BA can be affected by various disease processes, such as BA occlusion (1% of ischemic stroke) due to thrombus formation from atheromas (26–36%) or thrombus embolism (30–35%).[18] Further, BA aneurysm is another disease process, and the BA tip aneurysm variant

is the most common posterior circulation aneurysm (15% of all intracranial aneurysms).[9,17] BA vasospasm occurs after aneurysmal subarachnoid hemorrhage of the posterior circulation. In contrast to anterior circulation vasospasm, the BA vasospasm usually spares the brainstem from any infarction due to the abundant blood supply.[7]

Bibliometric analysis is a citation-based assessment of the significance and impact of individual articles in their respective fields. It is considered a new research method and was officially defined and introduced in 1969.[19] Bibliometric analysis has gradually gained the approval of the scientific community as it introduces interested clinicians of different specialties to the subject analyzed in the article.[8,16] It also explores the chronological trend of publication evolution, especially in relation to topics with large amounts of data in the literature. The utility of citation analysis is to conglomerate evidence-based studies and approaches to diseases while studying the changes in medical practice trends. Therefore, it holds paramount importance for young clinicians and scientists. Multiple citation analyses in neurosurgery have previously been published.[1,2,4] In the current paper, we present a bibliometric analysis of the top 100 articles on BA.

MATERIALS AND METHODS

The Scopus database was used to perform a title-specific search with no time restriction in June 2020, aiming to identify the most impactful articles published on BA "Basilar artery" was used as the keyword for the search to define the most-cited works on the same. The top 100 most-cited articles were selected for further analysis. Pertinent bibliometric parameters were obtained for analysis. The factors included the following: article-based parameters (Title, CC, C.Y., year of publication, and country of publication); journal-based parameters (publishing journal, SNIP, SJR, IF); and an author-based parameter (H-index, the specialty of the 1st author).

A comprehensive review of the most-cited articles was performed to classify them. The top 100 articles yielded were classified into the following eight categories: (1) clinical, (2) clinicopathological, (3) clinicoradiological, (4) endovascular management, (5) surgical management, (6) medical management, (7) neuroanatomical, and (8) experimental.

RESULTS

The data search included 3354 articles published between 1833 and 2020. The top 100 highly cited articles were published between 1946 and 2015, with a total of 13,595 citations and an average of 135.95 citations per article, in which the rate of self-citation for all authors accounted for 7.84% in the list [Table 1]. The most productive era of research on the BA was in the 1990s [Figure 1]. Over the 70 years, the top three most studied entities relevant to the BA were, in descending order, as follows: experimental, endovascular management, and clinical studies [Figure 2].

The United States of America was the country that contributed the most to the cited articles [Figure 3]. An analysis of the institutes that contributed three articles or more showed that the University of Bern has the highest number of articles in the list, accounting for ten articles [Figure 4]. Over the years of publication, the *Journal of Neurosurgery* contributed the most to the literature, accounting for 25 articles [Figure 5]. An in-depth assessment of the highest contributing authors by specialty showed that neuroradiologists' contributions were the most substantial at a total of 20 published articles. The most prolific author was Vanhoutte, a biologist who contributed to six articles on the list [Figure 6].

In *Stroke*, Brandt *et al*. (1996) published the most-cited article on the BA, titled "Thrombolytic therapy of acute BA occlusion: variables affecting recanalization and outcome." It received a total of 435 citations at 18.12 citations/year.

DISCUSSION

Initial studies of the top 100 cited articles on BA were diverse and mostly in the clinical category, with a significant focus on defining different disease patterns. BA thrombosis

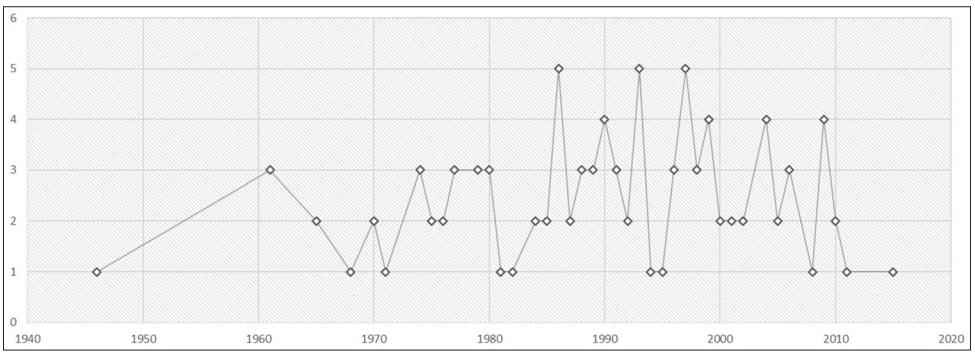

Figure 1: Chronological trends of the top-cited articles.

Table 1: The top 100 most-cited articles on the basilar artery.

Rank	Authors	Title	Journal	CC	CY
1st	Brandt *et al.*, 1996	Thrombolytic therapy of acute basilar artery occlusion: variables affecting recanalization and outcome	*Stroke*	435	18.12
2nd	Higashida *et al.*, 1997	Intravascular stent and endovascular coil placement for a ruptured fusiform aneurysm of the basilar artery. Case report and review of the literature	*Journal of Neurosurgery*	355	15.43
3rd	Schonewille *et al.*, 2009	Treatment and outcomes of acute basilar artery occlusion in the Basilar Artery International Cooperation Study (BASICS): a prospective registry study	*The Lancet Neurology*	345	31.36
4th	Lindsberg and Mattle, 2006	Therapy of basilar artery occlusion: a systematic analysis comparing intra-arterial and intravenous thrombolysis	*Stroke*	330	23.57
5th	Kawase *et al.*, 1985	Transpetrosal approach for aneurysms of the lower basilar artery	*Journal of Neurosurgery*	290	8.28
6th	Kubik and Adams, 1946	Occlusion of the basilar artery – a clinical and pathological study	*Brain*	269	3.53
7th	Steinberg, 1993	Deliberate basilar or vertebral artery occlusion in the treatment of intracranial aneurysms. Immediate results and long-term outcome in 201 patients	*Journal of Neurosurgery*	268	9.92
8th	Lanzino *et al.*, 1999	Efficacy and current limitations of intravascular stents for intracranial internal carotid, vertebral, and basilar artery aneurysms	*Journal of Neurosurgery*	264	12.57
9th	Saeki and Rhoton, 1977	Microsurgical anatomy of the upper basilar artery and the posterior circle of Willis	*Journal of Neurosurgery*	245	5.9
10th	Chimowitz, 1998	Prognosis of patients with symptomatic vertebral or basilar artery stenosis	*Stroke*	234	10.63
11th	Higashida *et al.*, 1993	Transluminal angioplasty for atherosclerotic disease of the vertebral and basilar arteries	*Journal of Neurosurgery*	232	8.59
12th	Archer and Horenstein, 1977	Basilar artery occlusion: clinical and radiological correlation	*Stroke*	228	5.3
13th	Bickerstaff, 1961	BASILAR ARTERY MIGRAINE	*The Lancet*	224	3.79
14th	Katusic *et al.*, 1984	Vasopressin causes endothelium-dependent relaxations of the canine basilar artery	*Circulation Research*	204	5.66
15th	Mattle *et al.*, 2011	Basilar artery occlusion	*The Lancet Neurology*	190	21.11
16th	Sundt *et al.*, 1980	Transluminal angioplasty for basilar artery stenosis	*Mayo Clinic Proceedings*	188	4.7
17th	Segarra, 1970	Cerebral Vascular Disease and Behavior: I. The Syndrome of the Mesencephalic Artery (Basilar Artery Bifurcation)	*Archives of Neurology*	182	3.64
18th	Fisher and Caplan, 1971	Basilar artery branch occlusion: a cause of pontine infarction	*Neurology*	182	3.71
19th	Smoker *et al.*, 1986	High-resolution computed tomography of the basilar artery. II. Vertebrobasilar dolichoectasia: clinical-pathologic correlation and review	*American Journal of Neuroradiology*	179	5.26
20th	Arnold *et al.*, 2004	Clinical and radiological predictors of recanalization and outcome of 40 patients with acute basilar artery occlusion treated with intra-arterial thrombolysis	*Journal of Neurology, Neurosurgery and Psychiatry*	179	11.18
21st	Percheron, 1976	Arteries of the human thalamus: II. Paramedian thalamic arteries and territories from the basilar communicating artery [LES ARTERES DU THALAMUS HUMAIN. II. ARTERES ET TERRITOIRES THALAMIQUES PARAMEDIANS DE L'ARTERE BASILAIRE COMMUNICANTE]	*Revue Neurologique*	178	4.04
22nd	Gomez *et al.*, 2000	Elective stenting of symptomatic basilar artery stenosis	*Stroke*	177	8.85
23rd	Spetzler *et al.*, 1988	Aneurysms of the basilar artery treated with circulatory arrest, hypothermia, and barbiturate cerebral protection	*Journal of Neurosurgery*	177	5.53
24th	Faraci, 1990	Role of nitric oxide in regulation of basilar artery tone *in vivo*	*American Journal of Physiology - Heart and Circulatory Physiology*	173	5.76

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Table 1: (*Continued*).

Rank	Authors	Title	Journal	CC	CY
25th	Ferbert *et al.*, 1990	Clinical features of proven basilar artery occlusion	*Stroke*	171	5.7
26th	Kulcsár *et al.*, 2010	High-profile flow diverter (Silk) implantation in the basilar artery: efficacy in the treatment of aneurysms and the role of the perforators	*Stroke*	155	15.5
27th	Lindsberg *et al.*, 2004	Long-term outcome after intravenous thrombolysis of basilar artery occlusion	*Journal of the American Medical Association*	152	9.5
28th	Voetsch *et al.*, 2004	Basilar artery occlusive disease in the New England Medical Center Posterior Circulation Registry	*Archives of Neurology*	150	9.375
29th	Day *et al.*, 1994	Extradural temporopolar approach to lesions of the upper basilar artery and infrachiasmatic region	*Journal of Neurosurgery*	148	5.69
30th	Katusic *et al.*, 1987	Endothelium-dependent contraction to stretch in canine basilar arteries	*American Journal of Physiology - Heart and Circulatory Physiology*	147	4.45
31st	Parsons *et al.*, 1989	5-HT1-like receptors mediate 5-hydroxytryptamine-induced contraction of human isolated basilar artery	*British Journal of Pharmacology*	146	4.7
32nd	Caplan, 1979	Occlusion of the vertebral or basilar artery: follow-up analysis of some patients with benign outcome	*Stroke*	142	3.46
33rd	Cross *et al.*, 1997	Relationship between clot location and outcome after basilar artery thrombolysis	*American Journal of Neuroradiology*	132	5.73
34th	Marquardt *et al.*, 2009	Incidence and prognosis of <50 symptomatic vertebral or basilar artery stenosis: prospective population-based study	*Brain*	128	11.63
35th	Puetz *et al.*, 2008	Extent of hypoattenuation on CT angiography source images predicts functional outcome in patients with basilar artery occlusion	*Stroke*	128	10.66
36th	Drake, 1961	Bleeding aneurysms of the basilar artery. Direct surgical management in four cases	*Journal of neurosurgery*	127	2.15
37th	Sasaki *et al.*, 1981	The effect of a lipid hydroperoxide of arachidonic acid on the canine basilar artery. An experimental study on cerebral vasospasm	*Journal of Neurosurgery*	125	3.2
38th	Pierot *et al.*, 1996	Selective occlusion of basilar artery aneurysms using controlled detachable coils: report of 35 cases	*Neurosurgery*	122	5.08
39th	Kitazono *et al.*, 1993	Role of ATP-sensitive K+ channels in CGRP-induced dilatation of basilar artery *in vivo*	*American Journal of Physiology - Heart and Circulatory Physiology*	120	4.44
40th	Schonewille *et al.*, 2005	Outcome in patients with basilar artery occlusion treated conventionally	*Journal of Neurology, Neurosurgery and Psychiatry*	120	8
41st	Bavinzski *et al.*, 1999	Treatment of basilar artery bifurcation aneurysms using Guglielmi detachable coils: a 6-year experience	*Journal of Neurosurgery*	118	5.61
42nd	Langton, 1993	Calcium channel currents recorded from isolated myocytes of rat basilar artery are stretch sensitive.	*The Journal of Physiology*	117	4.33
43rd	Smoker *et al.*, 1986	High-resolution computed tomography of the basilar artery: I. Normal size and position	*American Journal of Neuroradiology*	117	3.44
44th	Moufarrij *et al.*, 1986	Basilar and distal vertebral artery stenosis: long-term follow-up	*Stroke*	115	3.38
45th	Singer *et al.*, 2015	Mechanical recanalization in basilar artery occlusion: the ENDOSTROKE study	*Annals of Neurology*	114	23.4

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Table 1: (*Continued*).

Rank	Authors	Title	Journal	CC	CY
46th	Allen *et al.*, 1974	Cerebral arterial spasm. 1. In vitro contractile activity of vasoactive agents on canine basilar and middle cerebral arteries.	*Journal of neurosurgery*	114	2.47
47th	Klein *et al.*, 2010	Basilar artery atherosclerotic plaques in paramedian and lacunar pontine infarctions: a high-resolution MRI study	*Stroke*	112	11.2
48th	Kim *et al.*, 1992	Reduced production of cGMP underlies the loss of endothelium-dependent relaxations in the canine basilar artery after subarachnoid hemorrhage	*Circulation Research*	112	4
49th	Connor *et al.*, 1989	Characterization of 5-HT receptors mediating contraction of canine and primate basilar artery by use of GR43175, a selective 5-HT1-like receptor agonist	*British Journal of Pharmacology*	112	3.61
50th	Fisher, 1977	Bilateral occlusion of basilar artery branches	*Journal of Neurology, Neurosurgery and Psychiatry*	109	2.53
51st	Katusic *et al.*, 1993	Endothelium-dependent contractions to oxygen-derived free radicals in the canine basilar artery	*American Journal of Physiology - Heart and Circulatory Physiology*	109	4.03
52nd	Fujii *et al.*, 1991	Flow-mediated dilatation of the basilar artery *in vivo*	*Circulation Research*	109	3.75
53rd	Drake, 1975	Ligation of the vertebral (unilateral or bilateral) or basilar artery in the treatment of large intracranial aneurysms	*Journal of Neurosurgery*	109	2.42
54th	Katusic *et al.*, 1988	Endothelium-dependent contractions to calcium ionophore a23187, arachidonic acid, and acetylcholine in canine basilar arteries	*Stroke*	108	3.37
55th	Nishizaki *et al.*, 1986	Dolichoectatic basilar artery: a review of 23 cases	*Stroke*	104	3.05
56th	Mayhan, 1990	Impairment of endothelium-dependent dilatation of basilar artery during chronic hypertension	*American Journal of Physiology - Heart and Circulatory Physiology*	102	3.4
57th	Toda, 1974	The action of vasodilating drugs on isolated basilar, coronary, and mesenteric arteries of the dog.	*Journal of Pharmacology and Experimental Therapeutics*	102	2.21
58th	Phatouros *et al.*, 1999	Endovascular stenting of an acutely thrombosed basilar artery: technical case report and review of the literature	*Neurosurgery*	99	4.71
59th	Kim *et al.*, 1988	Alterations in endothelium-dependent responsiveness of the canine basilar artery after subarachnoid hemorrhage	*Journal of Neurosurgery*	99	3.09
60th	Mayer *et al.*, 2002	Treatment of basilar artery embolism with a mechanical extraction device: necessity of flow reversal	*Stroke*	97	5.39
61st	Allen and Banghart, 1979	Cerebral arterial spasm: Part 9. *In vitro* effects of nifedipine on serotonin-, phenylephrine-, and potassium-induced contractions of canine basilar and femoral arteries	*Neurosurgery*	97	2.36
62nd	Sturzenegger and Meienberg, 1985	Basilar Artery Migraine: a Follow-up Study of 82 Cases	*Headache: The Journal of Head and Face Pain*	95	2.71
63rd	Black and Ansbacher, 1984	Saccular aneurysm associated with segmental duplication of the basilar artery. A morphological study	*Journal of Neurosurgery*	94	2.61
64th	Wijdicks *et al.*, 1997	Intra-arterial thrombolysis in acute basilar artery thromboembolism: the initial mayo clinic experience	*Mayo Clinic Proceedings*	94	4.08
65th	Kwan *et al.*, 1991	Enlargement of basilar artery aneurysms following balloon occlusion – 'water-hammer effect'. Report of two cases	*Journal of Neurosurgery*	93	3.44

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Table 1: (*Continued*).

Rank	Authors	Title	Journal	CC	CY
66th	Chen *et al.*, 1997	Expression and function of recombinant endothelial nitric oxide synthase gene in canine basilar artery	*Circulation Research*	93	4.04
67th	Golden and French, 1975	Basilar artery migraine in young children	*Pediatrics*	92	2.04
68th	Cross *et al.*, 1998	Collateral circulation and outcome after basilar artery thrombolysis	*American Journal of Neuroradiology*	92	4.18
69th	Campos *et al.*, 1987	Saccular aneurysms in basilar artery fenestration	*American Journal of Neuroradiology*	91	2.75
70th	Gruber *et al.*, 1999	A comparison between endovascular and surgical management of basilar artery apex aneurysms	*Journal of Neurosurgery*	91	4.33
71st	Zeumer *et al.*, 1982	Local fibrinolysis in basilar artery thrombosis	*Deutsche Medizinische Wochenschrift*	91	2.39
72nd	Terada *et al.*, 1996	Transluminal angioplasty for arteriosclerotic disease of the distal vertebral and basilar arteries	*Journal of Neurology Neurosurgery and Psychiatry*	91	3.79
73rd	Abtin *et al.*, 1998	Basilar artery perforation as a complication of endoscopic third ventriculostomy	*Pediatric Neurosurgery*	90	4.09
74th	Nijensohn *et al.*, 1974	Clinical significance of basilar artery aneurysms	*Neurology*	89	1.93
75th	Sugita *et al.*, 1979	Microneurosurgery for aneurysms of the basilar artery	*Journal of Neurosurgery*	89	2.17
76th	Tosaka *et al.*, 2001	Sphingosine 1-phosphate contracts canine basilar arteries *in vitro* and *in vivo:* possible role in pathogenesis of cerebral vasospasm	*Stroke*	88	4.63
77th	Lee *et al.*, 1976	Neurogenic sympathetic vasoconstriction of the rabbit basilar artery	*Circulation Research*	88	2
78th	Devuyst *et al.*, 2002	Stroke or transient ischemic attacks with basilar artery stenosis or occlusion: clinical patterns and outcome	*Archives of Neurology*	87	4.83
79th	Echlin, 1965	Spasm of basilar and vertebral arteries caused by experimental subarachnoid hemorrhage.	*Journal of neurosurgery*	87	1.58
80th	von *et al.*, 1990	Evidence for two separate vasoconstriction-mediating nucleotide receptors, both distinct from the P2X-receptor, in rabbit basilar artery: a receptor for pyrimidine nucleotides and a receptor for purine nucleotides	*Naunyn-Schmiedeberg's Archives of Pharmacology*	87	2.9
81st	Sano, 1980	Temporopolar approach to aneurysms of the basilar artery at and around the distal bifurcation: technical note	*Neurological Research*	87	2.25
82nd	Valencia *et al.*, 2006	Blood flow dynamics in saccular aneurysm models of the basilar artery	*Journal of Biomechanical Engineering*	86	6.14
83rd	Zubkov *et al.*, 2000	Mechanism of endothelin-1-induced contraction in rabbit basilar artery	*Stroke*	86	4.3
84th	Drake, 1965	Surgical treatment of ruptured aneurysms of the basilar artery. Experience with 14 cases.	*Journal of neurosurgery*	86	1.56
85th	McDowell *et al.*, 1961	The natural history of internal carotid and vertebral-basilar artery occlusion	*Neurology*	85	1.44
86th	Hong *et al.*,	Vertebral artery dominance contributes to basilar artery curvature and peri-vertebrobasilar junctional infarcts	*Journal of Neurology, Neurosurgery and Psychiatry*	85	7.27
87th	Fujiwara *et al.*, 1986	Selective hemoglobin inhibition of endothelium-dependent vasodilation of rabbit basilar artery	*Journal of Neurosurgery*	85	2.5
88th	Tanishima, 1980	Cerebral vasospasm: contractile activity of hemoglobin in isolated canine basilar arteries	*Journal of Neurosurgery*	85	2.125
89th	Fisher, 1970	Occlusion of the Vertebral Arteries: causing Transient Basilar Symptoms	*Archives of Neurology*	84	1.68
90th	Wallace *et al.*, 1997	Basilar artery rethrombosis: successful treatment with platelet glycoprotein IIB/IIIA receptor inhibitor	*American Journal of Neuroradiology*	84	3.65

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Table 1: (*Continued*).

Rank	Authors	Title	Journal	CC	CY
91st	Kasuya *et al.*, 1995	Nitric oxide synthase and guanylate cyclase levels in canine basilar artery after subarachnoid hemorrhage	*Journal of Neurosurgery*	83	3.32
92nd	Lee and Sarwinski, 1991	Nitric oxidergic neurogenic vasodilation in the porcine basilar artery	*Journal of Vascular Research*	83	2.86
93rd	Mayhan, 1992	Impairment of endothelium-dependent dilatation of the basilar artery during diabetes mellitus	*Brain Research*	82	2.92
94th	Uda *et al.*, 2001	Endovascular treatment of basilar artery trunk aneurysms with Guglielmi detachable coils: clinical experience with 41 aneurysms in 39 patients	*Journal of Neurosurgery*	81	4.26
95th	Batjer and Samson, 1989	Causes of morbidity and mortality from surgery of aneurysms of the distal basilar artery	*Neurosurgery*	80	2.58
96th	Nagel *et al.*, 2009	Therapy of acute basilar artery occlusion: intra-arterial thrombolysis alone versus bridging therapy	*Stroke*	80	7.27
97th	Drake, 1968	The surgical treatment of aneurysms of the basilar artery.	*Journal of neurosurgery*	80	1.53
98th	Tanaka *et al.*, 2006	Relationship between variations in the circle of Willis and flow rates in internal carotid and basilar arteries determined by means of magnetic resonance imaging with semiautomated lumen segmentation: reference data from 125 healthy volunteers	*American Journal of Neuroradiology*	79	5.64
99th	Klein *et al.*, 2005	High-resolution MRI identifies basilar artery plaques in paramedian pontine infarct	*Neurology*	78	5.2
100th	Quiñones-Hinojosa *et al.*, 2004	Transcranial Motor Evoked Potentials during Basilar Artery Aneurysm Surgery: technique Application for 30 Consecutive Patients	*Neurosurgery*	78	4.87

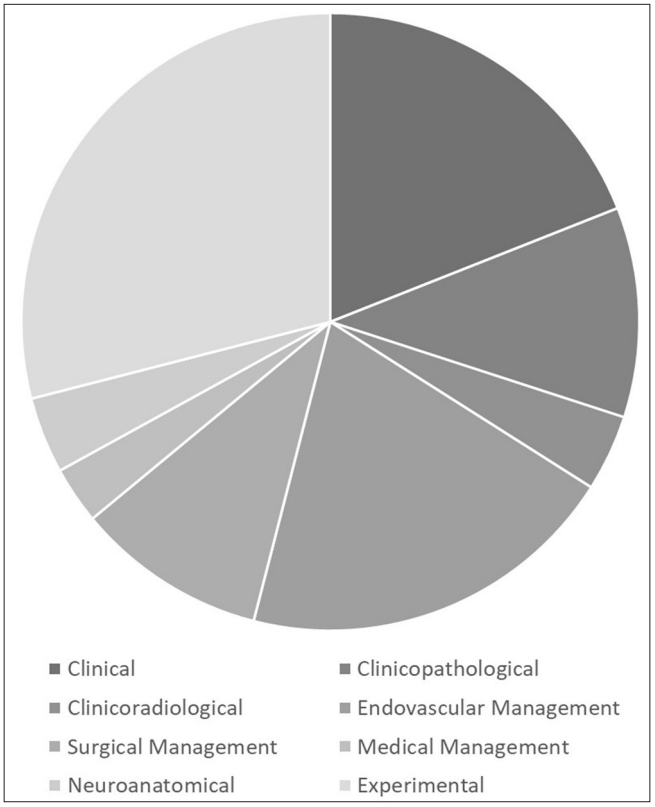

Figure 2: Different categories of the articles.

and migraine were popular in the 1900s–1960s. In the 1960s–1970s, authors were interested in studying the detailed surgical anatomy of the cerebral circulation, including BA. The natural history of BA aneurysm was dismal and with no active intervention until the 1960s, which was when renowned neurosurgeons attempted the first surgical management; similar publications surged in the 1970s on the different surgical techniques used in managing BA aneurysms. Experimental studies on cerebral vasospasm in animals were popular in the 1970s. In the 1980s, experimental studies on cerebral vasospasm in animals exponentially increased. The utilization of computed tomography (CT) to study the anatomy of BA and its different pathologies was also popular. Besides, endovascular techniques were of paramount interest for their utility in managing BA aneurysms and occlusion.

More publications using endovascular techniques were witnessed in the 1990s. Clinicians tried different endovascular modalities in managing BA aneurysms and thrombosis, such as coiling, stent-assisted coiling, or intravascular thrombolysis. Animal experiments on the molecular pathways of vasospasm continued with advancements in laboratory techniques. Studies comparing the efficacy and outcome of microsurgical and endovascular modalities in BA aneurysms management were published. Since the beginning of the 21st century, most of the publications have

Figure 3: Countries with the most contribution in the top-cited articles.

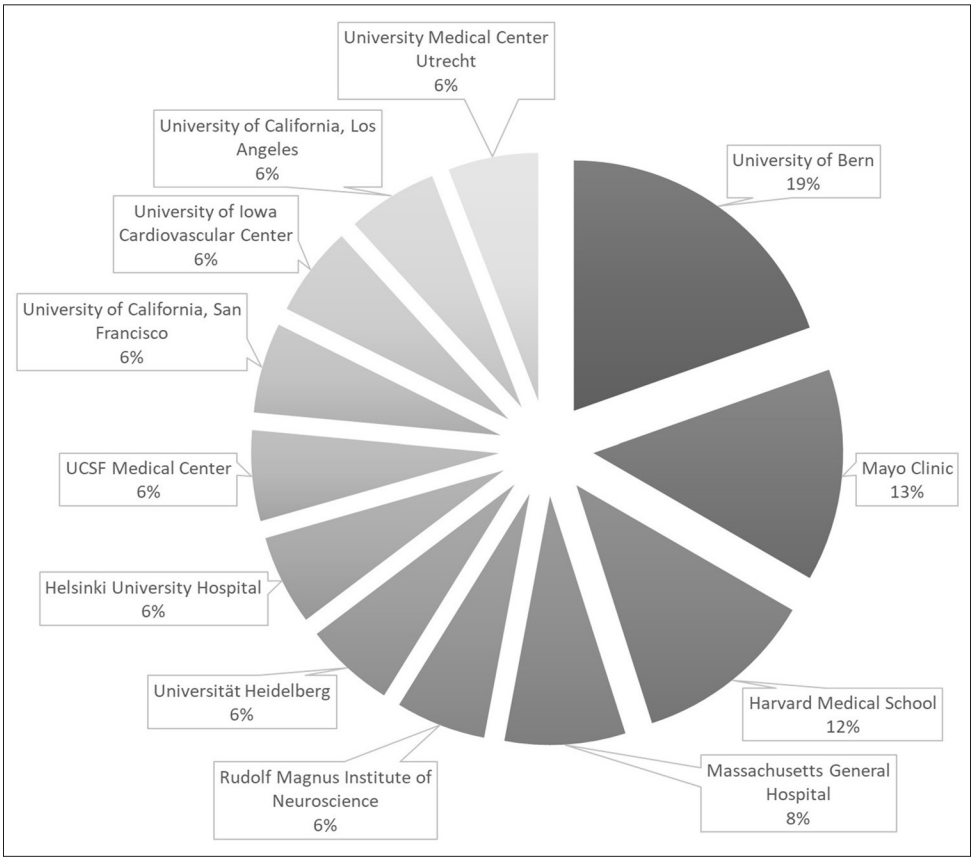

Figure 4: Institutions with the most contribution in the top-cited articles.

been on the endovascular management of BA aneurysms and thrombosis, and the pattern is rapidly evolving with newer techniques and devices.

The article with the highest number of citations overall (in both the medical and endovascular categories), that is, 435 CC and 18.12 CY, is "Thrombolytic therapy of acute BA occlusion: variables affecting recanalization and outcome" by Brandt *et al*. (1996) in *Stroke*. The study concluded that multiple important factors dictate the outcome of BA occlusion by a thrombus embolism or an atheroma. Patients who received intra-arterial or venous thrombolysis had a mortality rate of 46%, while the nonthrombolytic group had a 92% mortality

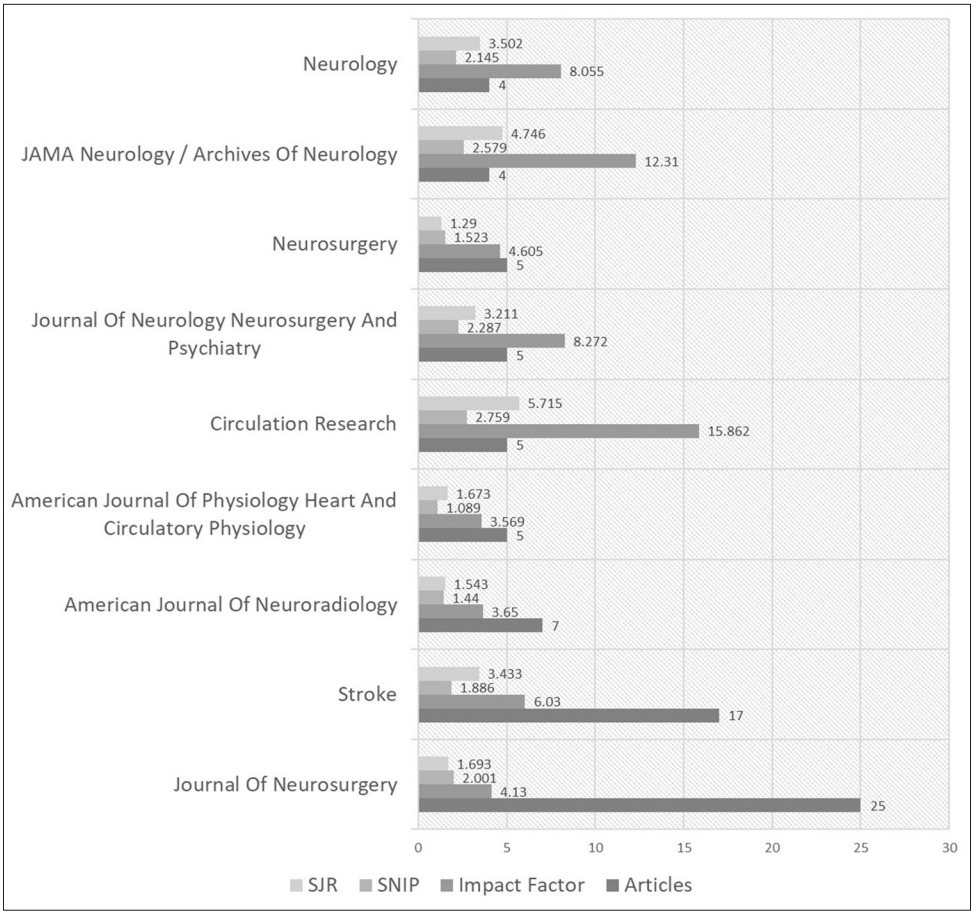

Figure 5: Journals with the most contribution in the top-cited articles.

rate ($P < 0.0004$). In addition, variables that affect mortality are the location of occlusion ($P < 0.0011$), patient's age ($P < 0.0008$), and collateral circulation status ($P < 0.04$).[6] The second highest cited article (second in the endovascular category), with 355 CC and 15.43 CY, is "Intravascular stent and endovascular coil placement for a ruptured fusiform aneurysm of the BA. Case report and review of the literature" by Higashida *et a*l. (1997) in the *Journal of Neurosurgery*. The article was the first of its kind to describe the endovascular management of a ruptured BA fusiform aneurysm using stents and Guglielmi detachable coils.[10]

Experimental category

The experimental category (peak publications in 1990–1997) had the highest publication number of all the categories. Studies performed on animal subjects in the 1970s and 1980s tested the vasospastic activities of BA in induced subarachnoid hemorrhage or the administration of vasoactive materials, such as serotonin and phenylephrine. Over the next years, researchers studied the intracellular pathways of vasospasm using BA and other intracranial vessels. Further, authors tested the various factors that may play a role in vasospasm, such as lipid hydroperoxides. Some authors researched the blood flow turbulence in vessels with aneurysms. The highest-cited article in the category (ranked 14th overall), with 204 CC and 5.66 CY, is "Vasopressin causes endothelium-dependent relaxations of the canine basilar artery" by Katusic *et al.* (1984) in *Circulation Research*. The experiments showed that endothelium mediates vascular relaxation induced by vasopressin; the absence of endothelium negates the vascular dilation activity of vasopressin.[11]

Endovascular category

The endovascular management category (peak publications in 1993–1999) contains one of the highest cited articles due to the revolutionary changes it brought with different, minimally invasive management of vascular pathologies. Initial papers help shed light on the possibility of managing BA occlusion with intra-arterial or venous thrombolysis. Simultaneously, other studies have demonstrated the efficacy of mechanical thrombectomy. Multiple articles published in the 1990s show the utility of stenting in BA stenosis. In addition, aneurysm research was possible due to evolutions

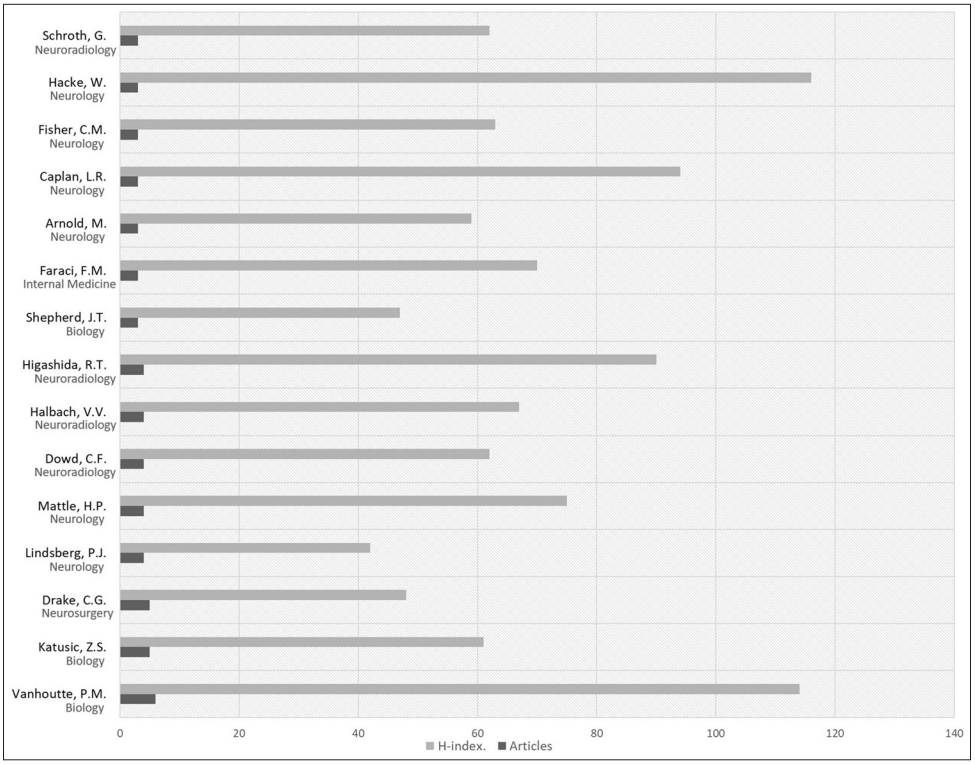

Figure 6: Authors with the most contribution in the top-cited articles.

in the different endovascular devices used for management, such as stent-assisted coiling. Afterward, flow diverters were introduced as a new modality to manage aneurysms. Some papers have compared the outcome of endovascular and surgical management of BA aneurysms.

The third highest cited article in the endovascular category (ranked 4th overall), with 330 CC and 23.57 CY, is "Therapy of BA occlusion: a systematic analysis comparing intra-arterial and intravenous thrombolysis" by Lindsberg and Mattle (2006) in *Stroke*. The authors found no difference between the outcomes of intravenous and intra-arterial thrombolysis; however, recanalization rates were higher in intra-arterial than in intravenous thrombolysis ($P < 0.05$).[14]

Clinical category

The clinical category (peak publications in 2002–2015) was mainly focused on the study of BA occlusion and stenosis from the 1960s to the 2010s. Most authors examined the natural history, outcome, and clinical presentation of BA occlusion and BA migraine. Different treatment modalities and their complications were described for BA occlusion over the following years.

The highest cited article in the clinical category (ranking 3rd overall), with 345 CC and the highest overall in terms of C.Y. (31.36), is "Treatment and outcomes of acute BA occlusion in the BA International Cooperation Study (BASICS): a prospective registry study" by Schonewille *et al*. (2009) in *The Lancet Neurology*. This study divides patients who have BA occlusion into three groups: antithrombotic treatment group, intravenous or intra-arterial thrombolysis group, or intra-arterial therapy (mechanical thrombectomy). In patients with mild-to-moderate clinical presentation, there was no difference in the outcomes of the three groups; patients with severe presentations were found to have an unfavorable prognosis in the antithrombotic treatment group as compared to intravenous/arterial thrombolysis or intra-arterial therapy. However, there was no difference between intravenous/arterial thrombolysis and intra-arterial therapy in the severe presentation group.[21]

Clinicopathologic category

The clinicopathologic category (peak publications in 1984–1987) focused on defining the clinical presentation and pathophysiology of BA occlusion, aneurysm, and dolichoectasia. The highest cited article in the category (ranked 6th overall), with 269 CC and 3.53 CY, is "Occlusion of the basilar artery – a clinical and pathological study" by Kubik and Adams (1946) in *Brain*. The authors examined 18 autopsies for BA occlusion and studied the mechanism of occlusion through thrombus embolism or atheroma-induced thrombosis, considering the symptomatology of this disease.[13]

Surgical category

The surgical management category had a bimodal peak publication in 1961–1968 and 1980–1988. In the 1960s, the technical notes of successful BA aneurysms clippings were surging, followed by alternative surgical approaches to aneurysms along the entire length of the BA. In the 1980s, some authors published papers on the utility of hypothermia, circulatory arrest, and barbiturate coma in surgically managing complex BA aneurysms. The highest cited article in the category (ranked 5th overall), with 290 CC and 8.28 CY, is "Transpetrosal approach for aneurysms of the lower basilar artery" by Kawase *et al*. (1985) in the *Journal of Neurosurgery*. The authors demonstrated that the extradural subtemporal approach and drilling of the anterior pyramidal bone yield a large operative corridor for proximal BA aneurysms, sparing the temporal lobe and cranial nerves and avoiding brainstem retraction injury.[12]

Neuroanatomy category

The neuroanatomy category publications peaked in 1976–1977. Initially, the authors studied the surgical anatomy of the posterior circulation, including the different variations of the BA's orientation, route, and branches. Further, the BA average caliber and variations were studied in addition to the essential perforators to the brainstem and thalamus. Later, articles were focused on the BA radio-anatomical correlation using CT scans and cadaveric specimens. The highest cited article in the category (ranked 9th overall), with 245 CC and 5.9 CY, is "Microsurgical anatomy of the upper basilar artery and the posterior circle of Willis" by Saeki and Rhoton Jr. (1977) in the *Journal of Neurosurgery*. The authors have described the detailed anatomy of the upper segment of the posterior circulation to the posterior cerebral arteries. The largest segment, branch, number of perforators in each segment, and incidence of different variations and hypoplastic vessels have been described.[20]

Clinicoradiological category

The clinicoradiological category (peak publications in 2005–2010) mainly consists of BA occlusion studies. Initial studies researched the radiological appearance of BA occlusion. In the 21st century, studies focused on high-resolution magnetic resonance imaging (MRI) to identify intra-luminal atheromas; concurrently, other studies used CT angiogram to predict functional outcome in patients with BA occlusion. The highest cited article in the category (ranked 12th overall), with 228 CC and 5.8 CY, is "Basilar artery occlusion: clinical and radiological correlation" by Archer and Horenstein (1977) in *Stroke*. The authors concluded that the extent of BA occlusion and low level of consciousness at presentation are poor prognostic factors.[3]

Medical management category

The medical management category (peak publications in 2004–2005) was focused on the use of antiplatelet or anticoagulation for the management of BA occlusion. Later, the authors compared observation-only management and the use of anti-platelets or anticoagulation for BA occlusion. The second highest cited article (ranked 27th overall), with 152 CC and 9.5 CY, is "Long-term outcome after intravenous thrombolysis of basilar artery occlusion" by Lindsberg *et al*. (2004) in *The Journal of the American Medical Association*. Patients who received intravenous thrombolysis were followed at 3 months and 1 year for functional outcome and survival. At 3 months, the recanalization rate was 52%, and mortality was 40%; 24% were functionally independent, while 16% had a severe functional disability. At 1 year, 30% reached functional independence, and 46% died.[15]

Limitations

Since the emergence of bibliometric reviews, many inherent limitations have been identified. The citation accumulation over time was found to be biased toward old articles, but the consideration of citations per year minimizes this predilection. The usage of citation count as a representative of the article's influence is not optimal for the following reasons: the number of citations does not reflect the value of the articles in a particular field, wherein peer-reviewed articles must be used with bibliometrics to complement the representation of field changing or impactful articles.[5]

Database-specific limitations in the Scopus search engine limit the full citation coverage dates in 1970–2020, and the citation count for articles published before this period may be underrepresented. Examination of the authors' self-citations as an inherent limitation of bibliometrics demonstrated a negligible effect in our study, at a rate of 7.4% for the total number of citations. Last, a publication in a highly impactful journal, based on their scientometric parameters, does not guarantee that all the publications in this journal are highly impactful in the studied field.[5]

CONCLUSION

The top-cited BA publications initially revolved around studying the natural history and management of BA occlusion, followed by the surgical anatomy of posterior circulation vessels. Subsequent articles focused on the surgical management of aneurysms and endovascular treatment of aneurysms as well as BA occlusion. Bibliometric analyses constitute a contemporary method of reviewing, analyzing, and summarizing highly cited articles. Most notably, top articles are cited for their impact in their respective fields and their evidence-based approach. We reviewed and analyzed the top 100 studies in BA to provide

an introductory article on BA multi-disciplinary publications for junior clinicians within related medical specialties. In addition, the publication trend may pave the way for novel research ideas in the future.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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