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Review Article

Bibliometric overview of the Top 100 most cited articles on hydrocephalus

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ABSTRACT

Background: Hydrocephalus is one of the most common brain disorders and numerous articles were published to address the clinical aspect and its management. This study aims to highlight the most influential work on hydrocephalus on bibliometric basis.

Methods: A thorough search of Scopus database was performed using the word "hydrocephalus." The 100 most cited articles were retrieved, and variables of importance were collected including the article's title, 1st author affiliation, country of origin, year and journal of publication, article's category, and citation count according to Scopus and Google scholar databases.

Results: The 100 most cited articles were thoroughly analyzed. Publication dates ranged from 1946 to 2014, with most articles (45) published between 1998 and 2007. The mean number of citations per publication was 201 with total of 20,177 citations. The United States of America contributed half of the articles. The leading institution was the Canadian hospital for Sick Children University of Toronto having published 5 articles. Hydrocephalus in general and normal pressure hydrocephalus was the two major categories addressed with most studies fall under the topic of surgical management. Neurosurgery was the specialty with the greatest contribution (47%). The articles were published in 46 different journals led by the Journal of Neurosurgery with total of 17 articles.

Conclusion: This bibliometric analysis delineates the landmark publications in hydrocephalus. The listed articles depict the myriad of studied aspects historically which helps in understanding hydrocephalus overall in evidence-based module for neurosurgeons and non-neurosurgeons.

Keywords: Bibliometric, Citation analysis, CSF diversion, CSF, Hydrocephalus

INTRODUCTION

Hydrocephalus is a complex condition that was first described by Hippocrates (466–377 BC), who described the associated symptoms of headache, vomiting, visual disturbance, and diplopia.[4] Throughout the years, the understanding of hydrocephalus has evolved, so it is identified as abnormal CSF physiology that results in pathological expansion of cerebral ventricles.[12] Although, many theories have been formulated to explain the molecular mechanism for development of hydrocephalus, the precise pathophysiology still unclear.[13,14] Hydrocephalus is one of the most common brain disorders that are estimated to possess mean prevalence of 85/100,000.[11] Substantial burden for both individual and society has been caused

by the chronic state of hydrocephalus.[7] It is a debilitating condition which can present at any age and encompasses heterogeneous pathogenesis.[13] Hydrocephalus causes are numerous, including but not limited to, tumors, congenital or non-congenital aqueductal stenosis, or genetic syndromes. It may also complicate a wide range of conditions such as infections, head injury, malformations, and subarachnoid hemorrhage.[1,11] Although there is no cure for hydrocephalus, early diagnosis and surgical intervention can improve morbidity, mortality, and quality of life.[6]

During the past decades, as a result of advancements in radiological imaging and basic neuroscientific study tool our understanding of hydrocephalus and our ability to manage and control it effectively.[16] These advancements are reflected in scientific articles, particularly in those most influential papers that covers different aspects including natural history, pathophysiology, epidemiology, etiology, diagnostic, and treatment strategies. An understanding of the available literature and the most heavily cited works can be used for scientific and clinical purposes.

Bibliometric analysis is defined as a statistical evaluation that aims to quantify the impact of scientific articles. The term "Bibliometrics" was first employed by Alan Pritchard in 1969.[10] A citation analysis is the most common bibliometric method which serves to review and evaluate the most-cited articles in a specific research area. It aims to identify landmark publications and recognize the level of contribution made by authors, specialties, institutions, countries, and journals.[9] There is certainly a considerable number of articles that are insufficiently valued by their citation counts (CCs) despite their importance. Nonetheless, the CC remains the accepted method internationally to assess an article's impact.

At present, citation analysis has been applied to identify articles in multiple medical and surgical fields.[15,18-20] Many analyses addressed neurosurgical topics such as meningioma,[3] acoustic neuroma,[2] low grade glioma,[5] idiopathic intracranial hypertension,[17] and yet none have been performed solely on hydrocephalus. We aimed to conduct a bibliometric analysis of the 100 most-cited works on hydrocephalus to analyze the current scientific production and to guide the health-care providers in this area.

MATERIALS AND METHODS

Search strategy

In March 2020, a title specific search was accomplished using Scopus database to identify the top 100 most cited articles on hydrocephalus. The search keyword that was used was hydrocephalus; another search keyword like "dilated ventricles, high intracranial pressure" was eliminated due to the non-specificity of the result to hydrocephalus. The search resultant was sorted in descending order according to CC. Google scholar CC was obtained by performing article title search and logging the CC of the article according to Google scholar database.

Data

Data of importance were collected and a comparative analysis between the published articles at basic six levels were made; article title, authors block, affiliation of the 1st author, country of origin, journal of publication, year of publication, CC according to Scopus database, and CC according to Google scholar database. The top 100 articles were categorized after studying the top 100 articles' abstracts to the following two categories and seven subcategories; hydrocephalus (Clinical/Epidemiological/Historical, Genetic Association, in intracranial hemorrhage, *in utero* Surgical Management, Pathophysiology, Radiological Assessment, RCT on shunt Valve types, Surgical Management), Normal pressure Hydrocephalus (Clinical/Epidemiological, Guidelines, Pathophysiology, Radiological Assessment, Surgical Management, and In Alzheimer disease).

Bibliometric parameters

Contemporarily, quantifying the importance of articles is achieved using bibliometric parameters which involve the CC of articles, Journal's SCImago Journal Rank (SJR), and Journal's Source-normalized Impact per paper (SNIP) for journals. The CC accounts for the number of accounted citations of a pertinent article since its publication. The SJR score, which signifies the journals influence by the number of citations the journal has received and the source of the received citation. The SNIP is a parameter which symbolizes how discipline specific is the journals based on the discipline of the journals in which citations was received.

RESULTS

Article analysis

The title specific search yielded a total of 12,044 articles. The top 100 articles based on the CC were collected and the following data were recorded (Title, 1st author, journal, year of publication, CC according to Scopus, and CC according to Google scholar) [Table 1]. Altogether, the top 100 articles accumulated a total of 20,177 CCs and an average CC of 201 citations. The percentage of self-citation in our bibliometric review accounted for only 6.6% according to Scopus data base. The most cited article was published in *The New England Journal of Medicine* by Adams *et al*. by the Massachusetts Medical Society in 1965 which addressed "Symptomatic Occult Hydrocephalus With Normal Cerebrospinal fluid pressure: a treatable Syndrome" for which it received 896 citations according to Scopus

Table 1: The list of the top 100 most-cited articles on hydrocephalus.

Rank	Title	1st Author	Journal	Year	CY	Scopus "CC"	Google Scholar "CC"
1st	Symptomatic occult hydrocephalus with "Normal"	Adams R.D.	The New England journal of medicine	1965	16.3	896	1619
2nd	The special clinical problem of symptomatic hydrocephalus with normal cerebrospinal fluid pressure. Observations on cerebrospinal fluid hydrodynamics	Hakim S.	Journal of the Neurological Sciences	1965	13.3	732	1266
3rd	Randomized trial of cerebrospinal fluid shunt valve design in pediatric hydrocephalus	Drake J.M.	Neurosurgery	1998	23.1	509	653
4th	X-linked spastic paraplegia (SPG1), MASA syndrome and X-linked hydrocephalus result from mutations in the L1 gene	Jouet M.	Nature Genetics	1994	13.2	344	433
5th	Neuropathological changes caused by hydrocephalus	Del Bigio M.R.	Acta Neuropathologica	1993	12.3	333	433
6th	Fetal surgery for myelomeningocele and the incidence of shunt-dependent hydrocephalus	Bruner J.P.	Journal of the American Medical Association	1999	15.5	326	435
7th	Acute hydrocephalus after aneurysmal subarachnoid hemorrhage	Van Gijn J.	Journal of Neurosurgery	1985	9.3	324	465
8th	Idiopathic normal pressure hydrocephalus: A systematic review of diagnosis and outcome	Hebb A.O.	Neurosurgery	2001	15.5	294	443
9th	The forkhead/winged helix gene Mf1 is disrupted in the pleiotropic mouse mutation congenital hydrocephalus	Jume T.	Cell	1998	12.6	277	347
10th	Alzheimer's disease, normal-pressure hydrocephalus, and senescent changes in CSF circulatory physiology: A hypothesis	Silverberg G.D.	Lancet Neurology	2003	16.1	273	389
11th	Catheter Shunts for Fetal Hydronephrosis and Hydrocephalus	Manning F.A.	New England Journal of Medicine	1986	7.6	259	290
12th	Normal-pressure hydrocephalus: Evaluation with cerebrospinal fluid flow measurements at MR imaging	Bradely Jr. W.G.	Radiology	1996	10.6	254	400
13th	Radiological assessment of hydrocephalus: New theories and implications for therapy	Gretiz D.	Neurosurgical Review	2004	15.4	247	417
14th	The physics of the cranial cavity. Hydrocephalus and normal pressure hydrocephalus: mechanical interpretation and mathematical model	Hakim S.	Surgical Neurology	1976	5.5	244	422
15th	Hydrocephalus: A previously unrecognized predictor of poor outcome from supratentorial intracerebral hemorrhage	Diringer M.N.	Stroke	1998	10.8	237	341
16th	The predictive value of conductance to outflow of CSF in normal pressure hydrocephalus	Borgesen S.E	Brain	1982	6.2	234	362
17th	Shunting normal–pressure hydrocephalus: Do the benefits outweigh the risks?: A multicenter study and literature review	Vanneste J.	Neurology	1992	8.1	228	328
18th	Dysfunction of axonemal dynein heavy chain Mdnah5 inhibits ependymal flow and reveals a novel mechanism for hydrocephalus formation	Ibanez-Tallon I.	Human Molecular Genetics	2004	14.1	225	307
19th	Aberrant splicing of neural cell adhesion molecule L1 mRNA in a family with X-linked hydrocephalus	Rosenthal A.	Nature Genetics	1992	7.9	222	280
20th	Dysfunctional cilia lead to altered ependyma and choroid plexus function, and result in the formation of hydrocephalus	Baniz B.	Development	2005	14.7	220	292

(Contd...)

Table 1: *(Continued)*.

Rank	Title	1st Author	Journal	Year	CY	Scopus "CC"	Google Scholar "CC"
21st	Risk factors for repeated cerebrospinal shunt failures in pediatric patients with hydrocephalus	Tuli S.	Journal of Neurosurgery	2000	11.0	219	333
22nd	Guidelines for management of idiopathic normal pressure hydrocephalus: Second edition	Mori E.	Neurologia Medico-Chirurgica	2012	27.3	218	307
23rd	Treatment of hydrocephalus by direct shunt from ventricle to jugular vein.	Nulsen F.E.	Surgical forum	1951	3.1	215	427
24th	Dutch normal-pressure hydrocephalus study: Prediction of outcome after shunting by resistance to outflow of cerebrospinal fluid	Boon A.J.W.	Journal of Neurosurgery	1997	9.2	212	288
25th	Comparative analysis of the gait disorder of normal pressure hydrocephalus and Parkinson's disease	Stolze H.	Journal of Neurology Neurosurgery and Psychiatry	2001	11.1	211	308
26th	Male infertility, impaired sperm motility, and hydrocephalus in mice deficient in sperm-associated antigen 6	Sapiro R.	Molecular and Cellular Biology	2002	11.7	210	247
27th	Diagnosis and management of normal-pressure hydrocephalus	Vanneste J.A.L.	Journal of Neurology	2000	10.5	210	320
28th	Increased central nervous system production of extracellular matrix components and development of hydrocephalus in transgenic mice overexpressing transforming growth factor-β1	Wyss. Coray T.	American Journal of Pathology	1995	8.3	207	245
29th	Hydrocephalus: Overdrainage by ventricular shunts. A review and recommendations	Pudenz R.H.	Surgical Neurology	1991	7.1	207	256
30th	CSF spaces in idiopathic normal pressure hydrocephalus: Morphology and volumetry	Kitagaki H.	American Journal of Neuroradiology	1998	9.4	206	274
31st	Management problems in acute hydrocephalus after subarachnoid hemorrhage	Hasan D.	Stroke	1989	6.6	204	321
32nd	Benign forms of intracranial hypertension-"toxic" and "otitic" hydrocephalus	Foley J.	Brain	1955	3.1	204	393
33rd	Diagnosis and management of idiopathic normal-pressure hydrocephalus: A prospective study in 151 patients	Marmarou A.	Journal of Neurosurgery	2005	13.5	203	309
34th	Lack of cadherins Celsr2 and Celsr3 impairs ependymal ciliogenesis, leading to fatal hydrocephalus	Tissir F.	Nature Neuroscience	2010	20.2	202	252
35th	Management of hydrocephalus by endoscopic third ventriculostomy in patients with myelomeningocele	Teo C.	Pediatric Neurosurgery	1996	8.4	201	261
36th	Hydrocephalus as a cause of disturbances of gait in the elderly	Fisher C.M.	Neurology	1982	5.3	201	305
37th	Risk factors for failure of endoscopic third ventriculostomy for obstructive hydrocephalus	Fukuhara T.	Neurosurgery	2000	10.0	200	270
38th	Diagnosis of idiopathic normal pressure hydrocephalus is supported by MRI-based scheme: A prospective cohort study	Hashimoto M.	Cerebrospinal Fluid Research	2010	19.7	197	266
39th	Schizencephalies: A study of the congenital clefts in the cerebral mantle: II. Clefts with hydrocephalus and lips separated	Yakovlev P.I.	Journal of Neuropathology and Experimental Neurology	1946	2.6	196	272
40th	Idiopathic normal-pressure hydrocephalus. Results of shunting in 62 patients	Black Mc L.P.	Journal of Neurosurgery	1980	4.9	194	330

(Contd...)

Table 1: *(Continued).*

Rank	Title	1st Author	Journal	Year	CY	Scopus "CC"	Google Scholar "CC"
41st	Frontal and occipital horn ratio: A linear estimate of ventricular size for multiple imaging modalities in pediatric hydrocephalus	O'Hayon B.B.	Pediatric Neurosurgery	1998	8.7	191	235
42nd	Factors related to hydrocephalus after aneurysmal subarachnoid hemorrhage	Dorai Z.	Neurosurgery	2003	11.2	190	322
43rd	The current status of endoscopic third ventriculostomy in the management of non-communicating hydrocephalus	Jones R.F.C.	Minimally Invasive Neurosurgery	1994	7.3	190	233
44th	A survey of the first complication of newly implanted CSF shunt devices for the treatment of nontumoral hydrocephalus - Cooperative survey of the 1991–1992 Education Committee of the ISPN	Di Rocco C.	Child's Nervous System	1994	7.3	189	221
45th	A randomized, controlled study of a programmable shunt valve versus a conventional valve for patients with hydrocephalus	Pollack I.F.	Neurosurgery	1999	8.9	186	198
46th	Anti-siphon and reversible occlusion valves for shunting in hydrocephalus and preventing post shunt subdural hematomas.	Portnoy H.D.	Journal of neurosurgery	1973	4.0	186	284
47th	Hydrocephalus: Changes in Formation and Absorption of Cerebrospinal	Bering Jr. W.G.	Journal of neurosurgery	1963	3.2	183	402
48th	The scientific history of hydrocephalus and its treatment	Aschoff A.	Neurosurgical Review	1999	8.6	181	335
49th	INPH guidelines, part I: Development of guidelines for idiopathic normal-pressure hydrocephalus: Introduction	Marmarou A.	Neurosurgery	2005	11.9	179	172
50th	Hydrocephalus in Uganda: The predominance of infectious origin and primary management with endoscopic third ventriculostomy	Warf B.C.	Journal of Neurosurgery	2005	11.9	178	252
51st	Intraventricular hemorrhage and hydrocephalus after spontaneous intracerebral hemorrhage: Results from the STICH trial	Bhattathiri P.S.	Acta Neurochirurgica, Supplementum	2006	12.6	177	276
52nd	Association of deep white matter infarction with chronic communicating hydrocephalus: Implications regarding the possible origin of normal-pressure hydrocephalus	Bradley Jr. W.G.	American Journal of Neuroradiology	1991	6.1	176	284
53rd	Alzheimer's disease comorbidity in normal pressure hydrocephalus: Prevalence and shunt response	Golomb.J.	Journal of Neurology Neurosurgery and Psychiatry	2000	8.8	175	254
54th	BDNF serum and CSF concentrations in Alzheimer's disease, normal pressure hydrocephalus and healthy controls	Laske C.	Journal of Psychiatric Research	2007	13.4	174	241
55th	Vascular Risk Factors and Arteriosclerotic Disease in Idiopathic Normal-Pressure Hydrocephalus of the Elderly	Krauss J.K.	Stroke	1996	7.3	174	232
56th	Central nervous system anomalies associated with meningomyelocele, hydrocephalus, and the Arnold-Chiari malformation: Reappraisal of theories regarding the pathogenesis of posterior neural tube closure defects	Gilbert J.N.	Neurosurgery	1986	5.1	174	248
57th	Clinical parameters in 74 consecutive patients shunt operated for normal pressure hydrocephalus	Larsson A.	Acta Neurologica Scandinavica	1991	6.0	173	225

(Contd...)

Table 1: *(Continued)*.

Rank	Title	1st Author	Journal	Year	CY	Scopus "CC"	Google Scholar "CC"
58th	Evidence that oxidative stress is associated with the pathophysiology of inherited hydrocephalus in the H-Tx rat model	Socci D.J.	Experimental Neurology	1999	8.2	172	205
59th	CRASH syndrome: Clinical spectrum of Corpus callosum hypoplasia, Retardation, Adducted thumbs, Spastic paraparesis and Hydrocephalus due to mutations in one single gene, L1	Fransen E.	European Journal of Human Genetics	1995	6.8	171	224
60th	Endoscopic Third Ventriculostomy in the Treatment of Childhood Hydrocephalus	Kulkarni A.V.	Journal of Pediatrics	2009	15.5	170	215
61st	Implanted ventricular shunts in the United States: The billion-dollar-a- year cost of hydrocephalus treatment	Patwardhan R.V.	Neurosurgery	2005	11.3	170	300
62nd	Disruption of the murine nuclear factor I-A gene results in perinatal lethality, hydrocephalus, and agenesis of the corpus callosum	Das Neves L.	Proceedings of the National Academy of Sciences of the United States of America	1999	8.0	168	207
63rd	Long-term results after ventriculoatrial and ventriculoperitoneal shunting for infantile hydrocephalus	Keucher T.R.	Journal of Neurosurgery	1979	4.1	168	270
64th	Dutch normal-pressure hydrocephalus study: Randomized comparison of low- and medium-pressure shunts	Boon A.J.W.	Journal of Neurosurgery	1998	7.6	167	239
65th	Measurement of optic nerve sheath diameter by ultrasound: A means of detecting acute raised intracranial pressure in hydrocephalus	Newman W.D.	British Journal of Ophthalmology	2002	9.2	166	284
66th	Diagnosis, treatment, and analysis of long-term outcomes in idiopathic normal-pressure hydrocephalus.	McGirt M.J.	Neurosurgery	2005	11.0	165	283
67th	The Predictive Value of Cerebrospinal Fluid Dynamic Tests in Patients With the Idiopathic Adult Hydrocephalus Syndrome	Malm J.	Archives of Neurology	1995	6.5	163	232
68th	Marked cerebrospinal fluid void: Indicator of successful shunt in patients with suspected normal-pressure hydrocephalus	Bradley Jr. W.G.	Radiology	1991	5.4	158	267
69th	Factors associated with hydrocephalus after subarachnoid hemorrhage: A report of the cooperative aneurysm study	Graff Radford N.R.	Archives of Neurology	1989	5.1	157	250
70th	Hospital care for children with hydrocephalus in the United States: Utilization, charges, comorbidities, and deaths	Simon T.D.	Journal of Neurosurgery: Pediatrics	2008	13.0	156	208
71st	Pattern of white matter regional cerebral blood flow and autoregulation in normal pressure hydrocephalus	Momjian S.	Brain	2004	9.8	156	221
72nd	Loss of function of axonemal dynein Mdnah5 causes primary ciliary dyskinesia and hydrocephalus	Ibanez-Tallon I.	Human Molecular Genetics	2002	8.5	153	191
73rd	Neurodevelopmental outcome of extremely low birth weight infants with posthemorrhagic hydrocephalus requiring shunt insertion	Adams-Chapman I.	Pediatrics	2008	12.7	152	176
74th	Relationship between cerebrospinal fluid formation, absorption and pressure in human hydrocephalus	Lorenzo A.V.	Brain	1970	3.0	152	278

(Contd...)

Table 1: *(Continued).*

Rank	Title	1st Author	Journal	Year	CY	Scopus "CC"	Google Scholar "CC"
75th	The value of temporary external lumbar CSF drainage in predicting the outcome of shunting on normal pressure hydrocephalus	Walchenbach R.	Journal of Neurology Neurosurgery and Psychiatry	2002	8.4	151	236
76th	The natural history of hydrocephalus: Detailed analysis of 182 unoperated cases	Laurence K.M.	Archives of Disease in Childhood	1962	2.5	147	267
77th	Reassessment of brain elasticity for analysis of biomechanisms of hydrocephalus	Taylor Z.	Journal of Biomechanics	2004	9.1	146	225
78th	Endoscopic third ventriculostomy in the management of obstructive hydrocephalus: An outcome analysis	Feng H.	Journal of Neurosurgery	2004	9.1	146	206
79th	Management of hydrocephalus in pediatric patients with posterior fossa tumors: The role of endoscopic third ventriculostomy	Sainte-Rose C.	Journal of Neurosurgery	2001	7.7	146	227
80th	Endoscopic third ventriculostomy for obstructive hydrocephalus	Hellwig D.	Neurosurgical Review	2005	9.6	144	243
81st	Stereotactic third ventriculostomy in patients with nontumoral adolescent/adult onset aqueductal stenosis and symptomatic hydrocephalus	Kelly P.J.	Journal of Neurosurgery	1991	4.9	143	179
82nd	The effect of intrauterine myelomeningocele repair on the incidence of shunt-dependent hydrocephalus	Tulipan N.	Pediatric Neurosurgery	2003	8.1	138	162
83rd	Diagnostic intracranial pressure monitoring and surgical management in idiopathic normal pressure hydrocephalus: A 6-Year review of 214 patients	Eide P.K.	Neurosurgery	2010	13.6	136	190
84th	Accelerated progression of kaolin-induced hydrocephalus in aquaporin-4-deficient mice	Bolch O.	Journal of Cerebral Blood Flow and Metabolism	2006	9.7	136	194
85th	Intracranial venous sinus hypertension: Cause or consequence of hydrocephalus in infants?	Sainte-Rose C.	Journal of Neurosurgery	1984	3.8	136	183
86th	Evaluation of an antibiotic-impregnated shunt system for the treatment of hydrocephalus	Govender S.T.	Journal of Neurosurgery	2003	7.9	135	166
87th	A Surgical Approach to the Treatment of Fetal Hydrocephalus	Clewell W.H.	New England Journal of Medicine	1982	3.6	135	240
88th	A standardized protocol to reduce cerebrospinal fluid shunt infection: The Hydrocephalus Clinical Research Network Quality Improvement Initiative. Clinical article	Kestle J.R.W.	Journal of Neurosurgery: Pediatrics	2011	14.8	133	162
89th	Guidelines for management of idiopathic normal pressure hydrocephalus: Guidelines from the Guidelines committee of idiopathic normal pressure hydrocephalus, the Japanese society of normal pressure hydrocephalus	Ishikawa M.	Neurologia Medico-Chirurgica	2008	11.1	133	196
90th	Chronic hydrocephalus in rats and humans: White matter loss and behavior changes	Del Bigio M.R.	Annals of Neurology	2003	7.8	133	175
91st	The clinical effect of lumbar puncture in normal pressure hydrocephalus	Wikkelso C.	Journal of Neurology Neurosurgery and Psychiatry	1982	3.5	132	202
92nd	Measurement of cerebrospinal fluid flow at the cerebral aqueduct by use of phase-contrast magnetic resonance imaging: Technique validation and utility in diagnosing idiopathic normal pressure hydrocephalus	Luetmer P.H.	Neurosurgery	2002	7.3	131	206

(Contd...)

Table 1: *(Continued)*.

Rank	Title	1st Author	Journal	Year	CY	Scopus "CC"	Google Scholar "CC"
93rd	The long-term outlook for hydrocephalus in childhood	Casey A.T.H.	Pediatric Neurosurgery	1997	5.7	131	182
94th	Cerebrospinal fluid shunting in idiopathic normal-pressure hydrocephalus of the elderly: Effect of periventricular and deep white matter lesions	Krauss J.K.	Neurosurgery	1996	5.5	131	184
95th	Hydrocephalus secondary to cysticercotic arachnoiditis. A long-term follow-up review of 92 cases	Sotelo J.	Journal of Neurosurgery	1987	4.0	131	197
96th	Prevalence of idiopathic normal-pressure hydrocephalus	Jaraj D.	Neurology	2014	21.7	130	182
97th	Normal pressure hydrocephalus. Predicting the results of cerebrospinal fluid shunting	Stein S.C.	Journal of Neurosurgery	1974	2.8	130	233
98th	A model of pulsations in communicating hydrocephalus	Egnor M.	Pediatric Neurosurgery	2002	7.2	129	208
99th	Specific patterns of cognitive impairment in patients with idiopathic normal pressure hydrocephalus and Alzheimer's disease: A pilot study	Iddon J.L.	Journal of Neurology Neurosurgery and Psychiatry	1999	6.1	129	190
100th	Intraventricular hemorrhage and hydrocephalus in premature newborns: A prospective study with CT	Burstein J.	American Journal of Roentgenology	1979	3.1	129	248

CC: Citation count, CY: Citation per year

database and 1619 citations according to Google Scholar Database. The range of publications started from 1946 to 2014 in which 45 articles were published between 1998 and 2007 which marks the most prolific epoch in publications history of hydrocephalus [Figure 1]. The United States of America contributed to half of top 100 most cited articles on hydrocephalus [Figure 2]. The Canadian hospital for Sick Children University of Toronto published 5 articles in our review as the most contributing institute [Figure 3]. A thorough review of the top 100 articles showed that two major categories were addressed: hydrocephalus in general and normal pressure hydrocephalus. The most studied topic falls under the umbrella of surgical management of hydrocephalus "18 articles" and the pathophysiology of hydrocephalus "14 articles" came as a 2nd in terms of study interest [Table 2]. A summary of the top 5 most cited articles and the relevant information in the study are summarized [Table 3].

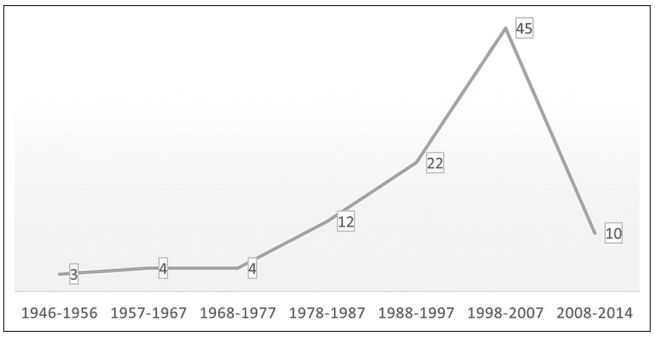

Figure 1: Trends of highly cited works on hydrocephalus.

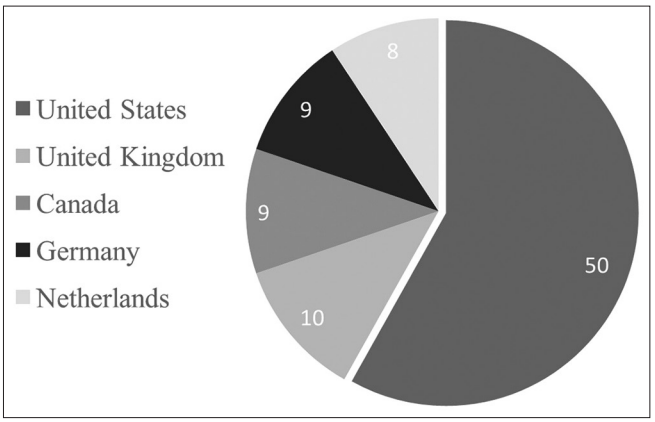

Figure 2: Top 5 most contributing countries to the most-cited works on hydrocephalus.

Author and journal analysis

In our review, around 160 authors have contributed to the top 100 most cited articles on hydrocephalus. The analysis of the contributing authors based on the 1st authors specialty demonstrated that neurosurgeons showed vast interest in hydrocephalus which accounted to approximately half of the articles in our bibliometric review [Figure 4]. A sub-analysis of the top 5 most contributing authors illustrated that Drake, J.M and Mori E both published four articles each

in our review with approximately equal author Hirsch Index (H index) of 65 and 64, respectively [Figure 5].

The enlisted top 100 most cited articles on hydrocephalus were contributed by 46 journals. Journal based quantified inspection illustrated that the top 5 most contributing journals were accountable for producing 43 articles in our review. The *Journal of Neurosurgery* (JNS) published 17 articles and the 2nd most ranked journal was the Neurosurgery Journal where it produced 12 articles the SNIP and SJR scores emphasized that JNS is more influential and field specific when compared to the neurosurgery journals [Figure 6].

Table 2: Studied Topics in the top 100 most cited articles on hydrocephalus.

Studied Topic	Number of articles
Hydrocephalus: Clinical/Epidemiological/History.	9
Hydrocephalus: Genetic Association.	10
Hydrocephalus: In Intracranial Hemorrhage.	8
Hydrocephalus: *In utero* Surgical Management.	4
Hydrocephalus: Pathophysiology.	14
Hydrocephalus: Radiological Assessment.	2
Hydrocephalus: RCT on Shunt Valve Types.	2
Hydrocephalus: Surgical Management.	18
Normal Pressure Hydrocephalus and Alzheimer Disease.	4
Normal Pressure Hydrocephalus: Clinical/ Epidemiological Review.	10
Normal Pressure Hydrocephalus: Guidelines.	3
Normal Pressure Hydrocephalus: Pathophysiology.	3
Normal Pressure Hydrocephalus: Radiological Assessment.	5
Normal Pressure Hydrocephalus: Surgical Management.	8

DISCUSSION

In the light of this bibliometric based evaluation of the impactful work on hydrocephalus to guide today's learner in the era of informational over satiety to denote important articles that need to be acknowledged.

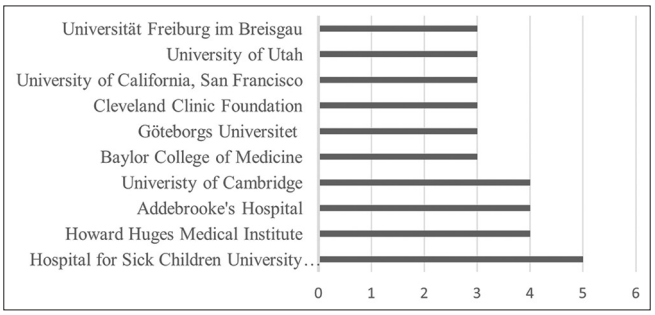

Figure 3: The topmost contributing institutes to the most-cited works on hydrocephalus.

Table 3: Summary of the 5 top 5 most cited articles on hydrocephalus.

Rank	Title	Summary
1st	Symptomatic Occult Hydrocephalus with "Normal" Cerebrospinal fluid pressure: A Treatable Syndrome.	1st clinical description of normal pressure hydrocephalus and how its diagnosed and the symptomatic relief with surgical ventricular shunting in 3 reported cases.
2nd	The Special clinical problem of symptomatic hydrocephalus with normal cerebrospinal fluid pressure: observation of Cerebrospinal Fluid Hydrodynamics.	A report of 3 cases where the 1st clinical depiction of normal pressure hydrocephalus syndrome presenting as mental dullness, psychomotor retardation, and incontinence with symptomatic relief after CSF diversion. Hydrodynamic explanation of dynamic press mechanism theory where ventricular elasticity and pressure on larger ventricles are inflicted in developing symptomatology.
3rd	Randomized Trial of Cerebrospinal Fluid Shunt Valve Design in Pediatric Hydrocephalus.	A comparative trial to assess the functional failure between Standard unidirectional valve, Delta Anti-siphon valve and orbis sigma with anti-siphon and pressure sensitive ring; Shunt failure rate from obstruction and infection in Delta or Orbis-Sigma showed no difference when compared to standard valve.
4th	X-Linked SPG1, MASA syndrome and X-linked Hydrocephalus result from mutations in the L1 Gene.	1st genetic associational discovery that states the missense mutation of L1/L1CAM responsible gene in SPG1, Hydrocephalus due to stenosis of aqueduct of sylvius "HSAS, and MASA syndrome. Also, spasticity involvement due to absence of CTS tract denotes that L1 protein have a major role in CTS development.
5th	Neuropathological Changes Caused by Hydrocephalus	A review on the neuropathological changes of hydrocephalus and changes after intervention showed that the severity depends on the rate of dilation, magnitude of dilation, proximal structures to the dilation and the developmental stage of occurrence. Microvascular disturbance, axonal and myelin changes, astroglial reaction, cortical damage and periventricular extracellular fluid accumulation occurred in hydrocephalic brains. Reversal of hydrocephalus induced neuropathological changes is possible and is correlated with the duration of hydrocephalus and the time of intervention.

CTS: Corticospinal, SPG1: Spastic Paraplegia G1

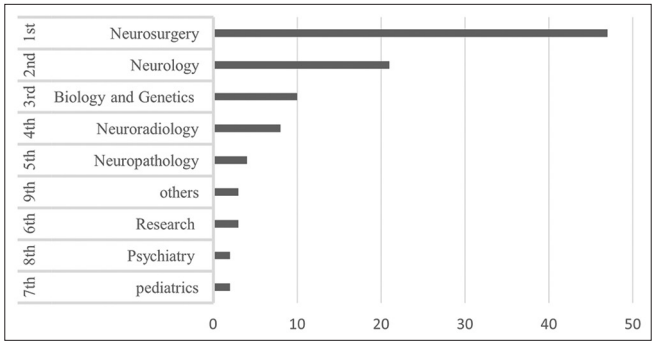

Figure 4: The list of contributing specialties to the most-cited articles on hydrocephalus.

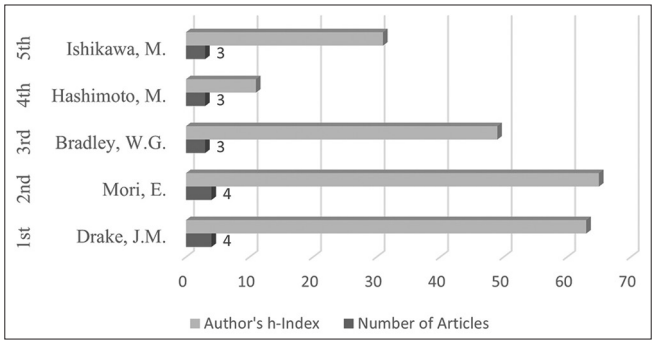

Figure 5: Top authors of contribution to the list.

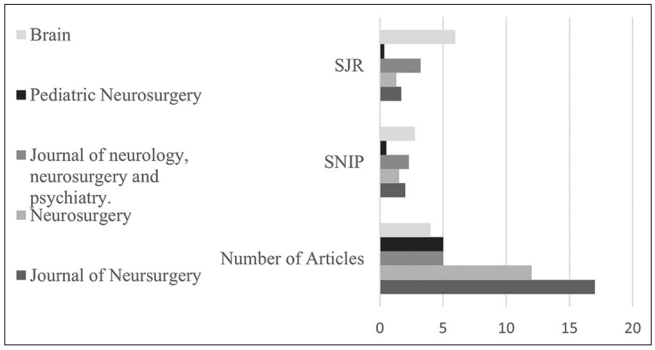

Figure 6: Top journals of contribution to the list.

The observation of the published work showed that the most impactful articles started from 1946 but interestingly only between 1998 and 2008 almost half of articles in our list were produced which could be related to the radiological advancement and increasing availability of brain imaging that was started in 1980 and continued to increase until 2010 according to a review by Edelman.[8] Notably, the predominance of hydrocephalus management existed in surgical intervention around 50% of our bibliometric analysis was contributed by neurosurgeons which emphasizes the role of neurosurgeons in this field. Various other specialties have contributed to our list as well such as neurology, genetics, radiology, and others indicating the diversity of medical professions dealing with the disease.

The major categories that were encountered when we reviewed the studied topics were mainly addressing hydrocephalus in general and normal pressure hydrocephalus. The majority of the articles were focused on the former (n = 67), in which the most studied subcategory was the surgical management (n = 18) followed by studies looking into the pathophysiology of hydrocephalus, our review also yielded two randomized controlled trials mainly comparing types of shunt valves. It is important to note that none of the studies that our research has yielded discussed medical therapy of hydrocephalus which supports that hydrocephalus is a surgical disease even with the recent advancement in research to medical therapy. The remainder of topics discussed genetic association (n = 10), hydrocephalus in intracranial hemorrhage and studies of radiological nature as well as other categories. Regarding normal pressure hydrocephalus, the most frequently studied topics were clinical or epidemiological review articles (n = 10) followed by surgical management studies (n = 8). A few studies were published focusing on the association with Alzheimer's disease and others outlining guidelines for management. The predominance of articles in our list studying hydrocephalus could probably be attributed to the incidence of the disease when compared to normal pressure hydrocephalus, as well as the more recent discovery of normal pressure hydrocephalus.

Our first ranked article was published in in 1965 by R. D. Adams titled "symptomatic occult hydrocephalus with normal cerebrospinal fluid pressure a treatable syndrome" which was released in the new England journal of medicine with a total CC of 896 (1619 citations on Google scholar). A follow-up paper after the one published by R. D. Adams and S. Hakim in the same year. The term normal pressure hydrocephalus was first introduced in this paper, which included three case reports of the condition while focusing on the clinical features as well as the diagnostic approach for the described entity, with strong focus was on the symptomology and suspected pathophysiology. The paper also addressed the variations of normal pressure hydrocephalus from other diseases that might mimic the conditions especially dementia as well as interpretations of the available investigations at the time. The paper stressed on the recognition of the syndrome due to the fact that the symptoms can subside with surgical ventricular shunting as demonstrated by their three presented cases.

Earlier in the year of 1965, S. Hakim and R. D. Adams published "The special clinical problem of symptomatic hydrocephalus with normal cerebrospinal fluid pressure, observations on cerebrospinal fluid hydrodynamics." The study reported three cases of hydrocephalus in the setting of normal cerebrospinal fluid pressure. They also described the triad of symptoms observed in these cases constituting of the

famous triad of mental derangement, gait disturbance and urinary incontinence. The researchers reported recovery of the condition by lowering the cerebrospinal fluid pressure by means of ventriculoatrial shunting, while hypothesizing on the possible mechanism of symptom formation. The article was published in the Journal of the Neurological Sciences receiving a CC of 732 in Scopus database (1266 citations on Google scholar) since its publication, placing it second in our list. Both of the studies paved the way for further clinical research by first describing this treatable entity, its clinical features and management by lowering CSF pressure by surgical shunting which remains the treatment of choice to this day.

Drake, J.M. was our highest-ranking author with the most contribution to our list (total of 4 articles) and an author H index of 63. Followed by Mori, E. with the same number of publications, however, Mori, E had a higher author H index of 65. The remaining authors in our top 5 list with highest contribution were Bradley, W.G., Hashimoto, M. and Ishikawa, M. by contributing three articles each. The authors were ranked based on the number of publications as well as the number of citations in their published works. Drake, J.M. has published one of the three randomized controlled trials in our list "Randomized trial of cerebrospinal fluid shunt valve design in pediatric hydrocephalus" in 1998. The article has made its way to our top ten list by accumulating a CC of 509 (653 citations on Google scholar). The study compared the delta valve, orbis sigma valve which were new at the time and the standard differential-pressure valve. The aim was to assess the shunt failure rate between the excess flow limiting valves and the standard differential pressure valves. Total of 344 patients were randomized and received one of the three valves. The study concluded that there was no significant difference in shunt failure rates after 1 year between the three valves. The article was released in *Neurosurgery*, which is the second ranking journal in our list with 12 article contribution to our list (SNIP and SJR of 1.523 and 1.29 respectively).

JNS published most of the articles in our list, by releasing 17 papers. One of which titled "Acute hydrocephalus after aneurysmal subarachnoid hemorrhage" published in 1985 by Van Gijn J was ranked 7th in our list by being cited 324 times. The study reported the incidence of hydrocephalus in 200 patients with diagnosed ruptured intracranial aneurysms. Hydrocephalus was evident in 20% of the studied cases. They also discussed the clinical and radiological features as well as management with external ventricular drain. JNS had a SNIP of 2 and a SJR of 1.69. *Journal of neurology, neurosurgery and psychiatry* (SNIP 2.28 and SJR 3.211), and *pediatric neurosurgery* (SNIP 0.492 and SJR 0.341) were placed in 3rd and 4th places, respectively, by releasing five articles each, followed by brain with a total contribution of four papers.

CONCLUSION

In this bibliometric analysis, we identified the top 100 most-cited articles with the term "hydrocephalus" using Scopus database. This study delineates the landmark publications in hydrocephalus. It identifies the articles that have addressed the historical development and provided key studies which highlight the important progress made in the field. The data presented reveals several characteristic related to the top contributions, including authors, institutions, type of study, and journal. The findings indicate that papers originating from outstanding institutions in North America and UK, published in high impact journals had the highest citations. Recognizing the most influential publications will provide an important framework to an enhanced understanding of the scientific advancements made in the field and identify potential area of research. It also serves as an efficient guide to achieving evidence-based clinical practice to optimize the outcome, which will help in reducing the disease burden.

Limitations

Inherent limitations exist when performing a citation analysis on a certain clinical topic. The database specific limitation exists where only one database was used to perform this review study. The extent of self-citation among all authors was not significant in our identified studies. The significance of highlighting the most-cited works on hydrocephalus does not necessarily confer the influence of any given article but it merely reflects and justify why the scientific committee have given it a high number of citations.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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