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The Top 100 Most-Cited Articles in Stroke Imaging: A Bibliometric Analysis

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Purpose: The goal of our study was to compile a list of the top 100 most-cited articles in stroke imaging literature across all peer-reviewed scientific journals. These articles were then analyzed to identify current trends in stroke imaging research and determine the characteristics of highly-cited articles.
Materials and Methods: A database of the top 100 most-cited articles was created using Scopus and Web of Science. Articles were reviewed for applicability by 2 fellowship-trained radiologists with over 10 years of combined experience in neuroimaging. The following information was collected from each article: Article Title, Scopus Citations, Year of Publication, Journal, Journal Impact Factor, Authors, Number of Institutions, Country of Origin, Study Topic, Study Design, and Sample Size.
Results: Citations for the top 100 most-cited articles ranged from 159-810, and citations per year ranged from 5.7-516.0. Most of articles were published between 1996 and 2000 ($n = 43$). Articles were published across 18 journals, most commonly in *Stroke* ($n = 40$). Magnetic resonance imaging was the focus in 46 articles, computed tomogrphy in 16, and functional magnetic resonance imaging in 10. The most common study topic is prognostic use of an imaging modality ($n = 27$).
Conclusions: Our study helps to characterize the field and identify the characteristics of most-cited articles.

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Introduction

Bibliometrics is the statistical analysis of scientific literature.[1-3] Several specialties and journals have previously compiled and published lists of the most-cited articles in their field.[4-17] According to our literature search, no current bibliometric analysis has focused specifically on stroke imaging in an English language journal.

Materials and Methods

A bibliometric analysis of the most-cited articles in stroke imaging was conducted in July 2016 using all journals from Elsevier's Scopus and Thomson Reuters' Web of Science. The terms were combined as follows:

("Stroke" OR "Cerebral infarct" OR "Cerebral infarction" OR "Cerebrovascular Accident" OR "CVA")

AND

("Neuroradiology" OR "Neuroimaging" OR "Brain imaging" OR "Brain CT" OR "Head CT" OR "CTA" OR "Computed tomography" OR "CT angiography" OR "Computed tomography angiography" OR "MRI" OR "MR Imaging" OR "Magnetic Resonance Imaging" OR "DWI" OR "DW imaging" OR "Diffusion-weighted imaging" OR "Diffusion-weighted imaging" OR "CTP" OR "CT Perfusion" OR "Computed tomography perfusion" OR "MR perfusion" OR "Magnetic resonance perfusion")

The articles were independently reviewed by 2 fellowship-trained radiologists with over 10 years of combined experience in neuroimaging. Exclusion criteria included review articles, guidelines, meta-analyses, transient ischemic attack studies, white

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Table 1
The 100 most-cited articles in stroke imaging literature

Rank	Article	Number of citations	Average number of citations per year
1	Warach S, Gaa J, Siewert B, Wielopolski P, Edelman RR. Acute human stroke studied by whole brain echo planar diffusion-weighted magnetic resonance imaging. Ann Neurol. 1995;37:231–241.	810	38.6
2	Barber PA, Demchuk AM, Zhang J, Buchan AM. Validity and reliability of a quantitative computed tomography score in predicting outcome of hyperacute stroke before thrombolytic therapy. Lancet. 2000;355:1670–1674.	748	46.8
3	Albers GW, Thijs VN, Wechsler L, Kemp S, Schlaug G, Skalabrin E, et al. Magnetic resonance imaging profiles predict clinical response to early reperfusion: The diffusion and perfusion-imaging evaluation for understanding stroke evolution (DEFUSE) study. Ann Neurol. 2006;60:508–517.	717	71.7
4	Cramer SC, Nelles G, Benson RR, Kaplan JD, Parker RA, Kwong KK, et al. A functional MRI study of subjects recovered from hemiparetic stroke. Stroke. 1997;28:2518–2527.	662	34.8
5	Warach S, Chien D, Li W, Ronthal M, Edelman RR. Fast magnetic resonance diffusion-weighted imaging of acute human stroke. Neurology. 1992;42:1717–1723.	662	27.6
6	Sorensen AG, Buonanno FS, Gonzalez RG, Schwamm LH, Lev MH, Huang- Hellinger FR, et al. Hyperacute stroke: Evaluation with combined multisection diffusion- weighted and hemodynamically weighted echo-planar MR imaging. Radiology. 1996;199: 391–401.	618	30.9
7	Kidwell CS, Jahan R, Gornbein J, Alger JR, Nenov V, Ajani Z, et al. A trial of imaging selection and endovascular treatment for ischemic stroke. New Engl J Med. 2013;368:914–923.	600	200.0
8	Campbell BCV, Mitchell PJ, Kleinig TJ, Dewey HM, Churilov L, Yassi N, et al. Endovascular therapy for ischemic stroke with perfusion-imaging selection. New Engl J Med. 2015;372:1009–1018.	516	516.0
9	Kidwell CS, Saver JL, Mattiello J, Starkman S, Vinuela F, Duckwiler G, et al. Thrombolytic reversal of acute human cerebral ischemic injury shown by diffusion/perfusion magnetic resonance imaging. Ann Neurol. 2000;47:462–469.	502	31.4
10	Ward NS, Brown MM, Thompson AJ, Frackowiak RSJ. Neural correlates of motor recovery after stroke: A longitudinal fMRI study. Brain. 2003;126:2476–2496.	495	38.1
11	Chalela JA, Kidwell CS, Nentwich LM, Luby M, Butman JA, Demchuk AM, et al. Magnetic resonance imaging and computed tomography in emergency assessment of patients with suspected acute stroke: a prospective comparison. Lancet. 2007;369:293–298.	480	53.3
12	Schlaug G, Benfield A, Baird AE, Siewert B, Lövblad KO, Parker RA, et al. The ischemic penumbra: Operationally defined by diffusion and perfusion MRI. Neurology. 1999;53:1528–1537.	478	28.1
13	Baird AE, Benfield A, Schlaug G, Siewert B, Lövblad K-, Edelman RR, et al. Enlargement of human cerebral ischemic lesion volumes measured by diffusion-weighted magnetic resonance imaging. Ann Neurol. 1997;41:581–589.	476	25.1
14	Barber PA, Darby DG, Desmond PM, Yang Q, Gerraty RP, Jolley D, et al. Prediction of stroke outcome with echo planar perfusion- and diffusion- weighted MRI. Neurology. 1998;51:418–426.	452	25.1
15	Von Kummer R, Allen KL, Holle R, Bozzao L, Bastianello S, Manelfe C, et al. Acute stroke: Usefulness of early CT findings before thrombolytic therapy. Radiology. 1997;205:327–333.	437	23.0
16	Neumann-Haefelin T, Wittsack H-, Wenserski F, Siebler M, Seitz RJ, Mödder U, et al. Diffusion- and perfusion-weighted MRI: The DWI/PWI mismatch region in acute stroke. Stroke. 1999;30:1591–1597.	422	24.8
17	Wintermark M, Flanders AE, Velthuis B, Meuli R, Van Leeuwen M, Goldsher D, et al. Perfusion-CT assessment of infarct core and penumbra: Receiver operating characteristic curve analysis in 130 patients suspected of acute hemispheric stroke. Stroke. 2006;37:979–985.	422	42.2
18	González RG, Schaefer PW, Buonanno FS, Schwamm LH, Budzik RF, Rordorf G, et al. Diffusion-weighted MR imaging: Diagnostic accuracy in patients imaged within 6 hours of stroke symptom onset. Radiology. 1999;210:155–162.	409	24.1
19	Von Kummer R, Meyding-Lamade U, Forsting M, Rosin L, Rieke K, Hacke W, et al. Sensitivity and prognostic value of early CT in occlusion of the middle cerebral artery trunk. Am J Neuroradiol. 1994;15:9–18.	409	18.6
20	Warach S, Dashe JF, Edelman RR. Clinical outcome in ischemic stroke predicted by early diffusion-weighted and perfusion magnetic resonance imaging: A preliminary analysis. J Cereb Blood Flow Metab. 1996;16:53–59.	399	20.0
21	Lövblad K, Laubach H, Baird AE, Curtin F, Schlaug G, Edelman RR, et al. Clinical experience with diffusion-weighted MR in patients with acute stroke. Am J Neuroradiol. 1998;19:1061–1066.	389	21.6
22	Wintermark M, Reichhart M, Thiran J, Maeder P, Chalaron M, Schnyder P, et al. Prognostic accuracy of cerebral blood flow measurement by perfusion computed tomography, at the time of emergency room admission, in acute stroke patients. Ann Neurol. 2002;51:417–432.	382	27.3
23	Lutsep HL, Albers GW, DeCrespigny A, Kamat GN, Marks MP, Moseley ME. Clinical utility of diffusion-weighted magnetic resonance imaging in the assessment of ischemic stroke. Ann Neurol. 1997;41:574–580.	377	19.8
24	Kidwell CS, Chalela JA, Saver JL, Starkman S, Hill MD, Demchuk AM, et al. Comparison of MRI and CT for detection of acute intracerebral hemorrhage. J Am Med Assoc. 2004;292:1823–1830.	368	30.7
25	Ward NS, Brown MM, Thompson AJ, Frackowiak RSJ. Neural correlates of outcome after stroke: A cross-sectional fMRI study. Brain. 2003;126:1430–1448.	368	28.3
26	Cao Y, D'Olhaberriague L, Vikingstad EM, Levine SR, Welch KMA. Pilot study of functional MRI to assess cerebral activation of motor function after poststroke hemiparesis. Stroke. 1998;29:112–122.	366	20.3
27	Carey JR, Kimberley TJ, Lewis SM, Auerbach EJ, Dorsey L, Rundquist P, et al. Analysis of fMRI and finger tracking training in subjects with chronic stroke. Brain. 2002;125:773–788.	362	25.9
28	Lövblad K-, Baird AE, Schlaug G, Benfield A, Siewert B, Voetsch B, et al. Ischemic lesion volumes in acute stroke by diffusion-weighted magnetic resonance imaging correlate with clinical outcome. Ann Neurol. 1997;42:164–170.	353	18.6
29	Longstreth Jr. WT, Bernick C, Manolio TA, Bryan N, Jungreis CA, Price TR. Lacunar infarcts defined by magnetic resonance imaging of 3660 elderly people: The cardiovascular health study. Arch Neurol.1998;55:1217–1225.	353	19.6
30	Chalela JA, Alsop DC, Gonzalez-Atavales JB, Maldjian JA, Kasner SE, Detre JA. Magnetic resonance perfusion-imaging in acute ischemic stroke using continuous arterial spin labeling. Stroke. 2000;31:680–687.	334	20.9
31	Parsons MW, Barber PA, Desmond PM, Baird TA, Darby DG, Byrnes G, et al. Acute hyperglycemia adversely affects stroke outcome: A magnetic resonance imaging and spectroscopy study. Ann Neurol. 2002;52:20–28.	333	23.8
32	Wolpert SM, Bruckmann H, Greenlee R, Wechsler L, Pessin MS, Del Zoppo GJ. Neuroradiologic evaluation of patients with acute stroke treated with recombinant tissue plasminogen activator. Am J Neuroradiol. 1993;14:3–13.	330	14.3
33	Tong DC, Yenari MA, Albers GW, O'Brien M, Marks MP, Moseley ME. Correlation of perfusion- and diffusion-weighted MRI with NIHSS score in acute ($<$ 6.5 hour) ischemic stroke. Neurology. 1998;50:864–870.	321	17.8

Table 1 (*continued*)

Rank	Article	Number of citations	Average number of citations per year
34	Sorensen AG, Copen WA, Østergaard L, Buonanno FS, Gonzalez RG, Rordorf G, et al. Hyperacute stroke: Simultaneous measurement of relative cerebral blood volume, relative cerebral blood flow, and mean tissue transit time. Radiology. 1999;210:519–527.	319	18.8
35	Beaulieu C, De Crespigny A, Tong DC, Moseley ME, Albers GW, Marks MP. Longitudinal magnetic resonance imaging study of perfusion and diffusion in stroke: Evolution of lesion volume and correlation with clinical outcome. Ann Neurol. 1999;46:568–578.	310	18.2
36	Fiebach JB, Schellinger PD, Jansen O, Meyer M, Wilde P, Bender J, et al. CT and diffusion-weighted MR imaging in randomized order: Diffusion-weighted imaging results in higher accuracy and lower interrater variability in the diagnosis of hyperacute ischemic stroke. Stroke. 2002;33:2206–2210.	302	21.6
37	Röther J, Schellinger PD, Gass A, Siebler M, Villringer A, Fiebach JB, et al. Effect of intravenous thrombolysis on MRI parameters and functional outcome in acute stroke <6 hours. Stroke. 2002;33:2438–2445.	296	21.1
38	Van Everdingen KJ, Van Der Grond J, Kappelle LJ, Ramos LMP, Mali WPTM. Diffusion-weighted magnetic resonance imaging in acute stroke. Stroke. 1998;29:1783–1790.	285	15.8
39	Schwamm LH, Koroshetz WJ, Sorensen A, Wang B, Copen WA, Budzik R, et al. Time course of lesion development in patients with acute stroke. Serial diffusion- and hemodynamic-weighted magnetic resonance imaging. Stroke. 1998;29:2268–2276.	283	15.7
40	Patel SC, Levine SR, Tilley BC, Grotta JC, Lu M, Frankel M, et al. Lack of clinical significance of early ischemic changes on computed tomography in acute stroke. J Am Med Assoc. 2001;286:2830–2838.	275	18.3
41	Wintermark M, Thiran J-, Maeder P, Schnyder P, Meuli R. Simultaneous measurement of regional cerebral blood flow by perfusion CT and stable xenon CT: A validation study. Am J Neuroradiol. 2001;22:905–914.	260	17.3
42	Werring DJ, Toosy AT, Clark CA, Parker GJM, Barker GJ, Miller DH, et al. Diffusion tensor imaging can detect and quantify corticospinal tract degeneration after stroke. J Neurol Neurosurg Psychiatry. 2000;69:269–272.	256	16.0
43	Fiebach JB, Schellinger PD, Gass A, Kucinski T, Siebler M, Villringer A, et al. Stroke Magnetic Resonance Imaging Is Accurate in Hyperacute Intracerebral Hemorrhage: A Multicenter Study on the Validity of Stroke Imaging. Stroke. 2004;35:502–506.	254	21.2
44	Wintermark M, Reichhart M, Cuisenaire O, Maeder P, Thiran J-, Schnyder P, et al. Comparison of admission perfusion computed tomography and qualitative diffusion- and perfusion-weighted magnetic resonance imaging in acute stroke patients. Stroke. 2002;33:2025–2031.	253	18.1
45	Marks MP, De Crespigny A, Lentz D, Enzmann DR, Albers GW, Moseley ME. Acute and chronic stroke: Navigated spin-echo diffusion-weighted MR imaging. Radiology. 1996;199:403–408.	247	12.4
46	Kidwell CS, Saver JL, Villablanca JP, Duckwiler G, Fredieu A, Gough K, et al. Magnetic resonance imaging detection of microbleeds before thrombolysis: An emerging application. Stroke. 2002;33:95–98.	247	17.6
47	Pexman JHW, Barber PA, Hill MD, Sevick RJ, Demchuk AM, Hudon ME, et al. Use of the Alberta Stroke Program Early CT Score (ASPECTS) for assessing CT scans in patients with acute stroke. Am J Neuroradiol. 2001;22:1534–1542.	247	16.5
48	Wada R, Aviv RI, Fox AJ, Sahlas DJ, Gladstone DJ, Tomlinson G, et al. CT angiography “spot sign” predicts hematoma expansion in acute intracerebral hemorrhage. Stroke. 2007;38:1257–1262.	246	27.3
49	Sorensen AG, Wu O, Copen WA, Davis TL, Gonzalez RG, Koroshetz WJ, et al. Human acute cerebral ischemia: Detection of changes in water diffusion anisotropy by using MR imaging. Radiology. 1999;212:785–792.	245	14.4
50	Koenig M, Klotz E, Luka B, Venderink DJ, Spittler JF, Heuser L. Perfusion CT of the brain: Diagnostic approach for early detection of ischemic stroke. Radiology. 1998;209:85–93.	244	13.6
51	Lev MH, Segal AZ, Farkas J, Hossain ST, Putman C, Hunter GJ, et al. Utility of perfusion-weighted CT imaging in acute middle cerebral artery stroke treated with intra-arterial thrombolysis: Prediction of final infarct volume and clinical outcome. Stroke. 2001;32:2021–2027.	244	16.3
52	Lansberg MG, Straka M, Kemp S, Mlynash M, Wechsler LR, Jovin TG, et al. MRI profile and response to endovascular reperfusion after stroke (DEFUSE 2): A prospective cohort study. Lancet Neurol. 2012;11:860–867.	242	60.5
53	Kahlert P, Knipp SC, Schlamann M, Thielmann M, Al-Rashid F, Weber M, et al. Silent and apparent cerebral ischemia after percutaneous transfemoral aortic valve implantation: A diffusion-weighted magnetic resonance imaging study. Circulation. 2010;121:870–878.	239	39.8
54	Schellinger PD, Jansen O, Fiebach JB, Hacke W, Sartor K. A standardized MRI stroke protocol: Comparison with CT in hyperacute intracerebral hemorrhage. Stroke. 1999;30:765–768.	238	14.0
55	Kato H, Izumiyama M, Izumiyama K, Takahashi A, Itoyama Y. Silent cerebral microbleeds on T2*-weighted MRI: Correlation with stroke subtype, stroke recurrence, and leukoaraiosis. Stroke. 2002;33:1536–1540.	231	16.5
56	Nighoghossian N, Hermier M, Adeleine P, Blanc-Lasserre K, Derex L, Honnorat J, et al. Old microbleeds are a potential risk factor for cerebral bleeding after ischemic stroke: A gradient-echo T2*-weighted brain MRI study. Stroke. 2002;33:735–742.	227	16.2
57	Grefkes C, Nowak DA, Eickhoff SB, Dafotakis M, Küst J, Karbe H, et al. Cortical connectivity after subcortical stroke assessed with functional magnetic resonance imaging. Ann Neurol. 2008;63:236–246.	225	28.1
58	Brott T, Marler JR, Olinger CP, Adams HP, Tomsick T, Barsan WG, et al. Measurements of acute cerebral infarction: Lesion size by computed tomography. Stroke. 1989;20:871–875.	225	8.3
59	Cao Y, Vikingstad EM, George KP, Johnson AF, Welch KMA. Cortical language activation in stroke patients recovering from aphasia with functional MRI. Stroke. 1999;30:2331–2340.	223	13.1
60	Schramm P, Schellinger PD, Klotz E, Kallenberg K, Fiebach JB, Külkens S, et al. Comparison of perfusion computed tomography and computed tomography angiography source images with perfusion-weighted imaging and diffusion-weighted imaging in patients with acute stoke of less than 6 hours' duration. Stroke. 2004;35:1652–1657.	221	18.4
61	Von Kummer R, Bourquain H, Bastianello S, Bozzao L, Manelfe C, Meier D, et al. Early prediction of irreversible brain damage after ischemic stroke at CT. Radiology. 2001;219:95–100.	218	14.5
62	Chien D, Kwong KK, Gress DR, Buonanno FS, Buxton RB, Rosen BR, et al. MR diffusion imaging of cerebral infarction in humans. Am J Neuroradiol. 1992;13:1097–1106.	218	9.1
63	Bryan RN, Levy LM, Whitlow WD, Killian JM, Preziosi TJ, Rosario JA. Diagnosis of acute cerebral infarction: Comparison of CT and MR imaging. Am J Neuroradiol. 1991;12:611–620.	216	8.6
64	Marchal G, Beaudouin V, Rioux P, De La Sayette V, Le Doze F, Viader F, et al. Prolonged persistence of substantial volumes of potentially viable brain tissue after stroke: A correlative PET-CT study with voxel-based data analysis. Stroke. 1996;27:599–606.	216	10.8
65	Rordorf G, Koroshetz WJ, Copen WA, Cramer SC, Schaefer PW, Budzik Jr. RF, et al. Regional ischemia and ischemic injury in patients with acute middle cerebral artery stroke as defined by early diffusion-weighted and perfusion- weighted MRI. Stroke. 1998;29:939–943.	215	11.9
66	Carter AR, Astafiev SV, Lang CE, Connor LT, Rengachary J, Strube MJ, et al. Resting interhemispheric functional magnetic resonance imaging connectivity predicts performance after stroke. Ann Neurol. 2010;67:365–375.	215	35.8

Table 1 (*continued*)

Rank	Article	Number of citations	Average number of citations per year
67	Mullins ME, Schaefer PW, Sorensen AG, Halpern EF, Ay H, He J, et al. CT and conventional and diffusion-weighted MR imaging in acute stroke: Study in 691 patients at presentation to the emergency department. Radiology. 2002;224:353–360.	214	15.3
68	Price TR, Manolio TA, Kronmal RA, Kittner SJ, Yue NC, Robbins J, et al. Silent brain infarction on magnetic resonance imaging and neurological abnormalities in community-dwelling older adults: The Cardiovascular Health Study. Stroke. 1997;28:1158–1164.	214	11.3
69	Kuhl DE, Phelps ME, Kowell AP, Metter EJ, Selin C, Winter J. Effects of stroke on local cerebral metabolism and perfusion: Mapping by emission computed tomography of 18FDG and 13NH 3. Ann Neurol. 1980;8:47–60.	204	5.7
70	Krieger DW, Demchuk AM, Kasner SE, Jauss M, Hantson L. Early clinical and radiological predictors of fatal brain swelling in ischemic stroke. Stroke. 1999;30:287-292.	203	11.9
71	Bammer R, Keeling SL, Augustin M, Pruessmann KP, Wolf R, Stollberger R, et al. Improved diffusion-weighted single-shot echo-planar imaging (EPI) in stroke using sensitivity encoding (SENSE). Magn Reson Med. 2001;46:548–554.	203	13.5
72	Eastwood JD, Lev MH, Azhari T, Lee T-, Barboriak DP, Delong DM, et al. CT perfusion scanning with deconvolution analysis: Pilot study in patients with acute middle cerebral artery stroke. Radiology. 2002;222:227–236.	202	14.4
73	Mayer TE, Hamann GF, Baranczyk J, Rosengarten B, Klotz E, Wiesmann M, et al. Dynamic CT perfusion imaging of acute stroke. Am J Neuroradiol. 2000;21:1441–1449.	202	12.6
74	Darby DG, Barber PA, Gerraty RP, Desmond PM, Yang Q, Parsons M, et al. Pathophysiological topography of acute ischemia by combined diffusion- weighted and perfusion MRI. Stroke. 1999;30:2043–2052.	199	11.7
75	Schellinger PD, Thomalla G, Fiehler J, Köhrmann M, Molina CA, Neumann-Haefelin T, et al. MRI-based and CT-based thrombolytic therapy in acute stroke within and beyond established time windows: An analysis of 1210 patients. Stroke. 2007;38:2640–2645.	195	21.7
76	Koenig M, Kraus M, Theek C, Klotz E, Gehlen W, Heuser L. Quantitative assessment of the ischemic brain by means of perfusion-related parameters derived from perfusion CT. Stroke. 2001;32:431–437.	191	12.7
77	Wu O, Koroshetz WJ, Østergaard L, Buonanno FS, Copen WA, Gonzalez RG, et al. Predicting tissue outcome in acute human cerebral ischemia using combined diffusion- and perfusion-weighted MR imaging. Stroke. 2001;32:933–942.	190	12.7
78	Oppenheim C, Samson Y, Manai R, Lalam T, Vandamme X, Crozier S, et al. Prediction of malignant middle cerebral artery infarction by diffusion-weighted imaging. Stroke. 2000;31:2175–2181.	190	11.9
79	Grotta JC, Chiu D, Lu M, Patel S, Levine SR, Tilley BC, et al. Agreement and variability in the interpretation of early CT changes in stroke patients qualifying for intravenous rtPA therapy. Stroke. 1999;30:1528–1533.	188	11.1
80	Oppenheim C, Stanescu R, Dormont D, Crozier S, Marro B, Samson Y, et al. False-negative diffusion-weighted MR findings in acute ischemic stroke. Am J Neuroradiol. 2000;21:1434–1440.	186	11.6
81	Klotz E, König M. Perfusion measurements of the brain: Using dynamic CT for the quantitative assessment of cerebral ischemia in acute stroke. Eur J Radiol. 1999;30:170–184.	183	10.8
82	Tomsick T, Brott T, Barsan W, Broderick J, Clarke Haley E, Spilker J, et al. Prognostic value of the hyperdense middle cerebral artery sign and stroke scale score before ultraearly thrombolytic therapy. Am J Neuroradiol. 1996;17:79–85.	182	9.1
83	Moulin T, Cattin F, Crépin-Leblond T, Tatu L, Chavot D, Piotin M, et al. Early CT signs in acute middle cerebral artery infarction: Predictive value for subsequent infarct locations and outcome. Neurology. 1996;47:366-375.	181	9.1
84	Mohr JP, Biller J, Hilal SK, Yuh WTC, Tatemichi TK, Hedges S, et al. Magnetic resonance versus computed tomographic imaging in acute stroke. Stroke. 1995;26:807–812.	180	8.6
85	Welch KMA, Windham J, Knight RA, Nagesh V, Hugg JW, Jacobs M, et al. A model to predict the histopathology of human stroke using diffusion and t sub 2-weighted magnetic resonance imaging. Stroke. 1995;26:1983–1989.	179	8.5
86	Truwit CL, Barkovich AJ, Gean-Marton A, Hibri N, Norman D. Loss of the insular ribbon: Another early CT sign of acute middle cerebral artery infarction. Radiology. 1990;176:801–806.	176	6.8
87	Schellinger PD, Jansen O, Fiebach JB, Heiland S, Steiner T, Schwab S, et al. Monitoring intravenous recombinant tissue plasminogen activator thrombolysis for acute ischemic stroke with diffusion and perfusion MRI. Stroke. 2000;31:1318–1328.	176	11.0
88	Yuh WTC, Crain MR, Loes DJ, Greene GM, Ryals TJ, Sato Y. MR imaging of cerebral ischemia: Findings in the first 24 hours. Am J Neuroradiol. 1991;12:621–629.	176	7.0
89	Røhl L, Østergaard L, Simonsen CZ, Vestergaard-Poulsen P, Andersen G, Sakoh M, et al. Viability thresholds of ischemic penumbra of hyperacute stroke defined by perfusion-weighted MRI and apparent diffusion coefficient. Stroke. 2001;32:1140–1146.	176	11.7
90	Levy CE, Nichols DS, Schmalbrock PM, Keller P, Chakeres DW. Functional MRI evidence of cortical reorganization in upper-limb stroke hemiplegia treated with constraint-induced movement therapy. Am J Phys Med Rehabil. 2001;80:4–12.	175	11.7
91	Köhrmann M, Jüttler E, Fiebach JB, Huttner HB, Siebert S, Schwark C, et al. MRI versus CT-based thrombolysis treatment within and beyond the 3 hour time window after stroke onset: A cohort study. Lancet Neurol. 2006;5:661–667.	173	17.3
92	Sobesky J, Weber OZ, Lehnhardt F-, Hesselmann V, Neveling M, Jacobs A, et al. Does the mismatch match the penumbra? Magnetic resonance imaging and positron emission tomography in early ischemic stroke. Stroke. 2005;36:980–985.	172	15.6
93	Lee LJ, Kidwell CS, Alger J, Starkman S, Saver JL. Impact on stroke subtype diagnosis of early diffusion-weighted magnetic resonance imaging and magnetic resonance angiography. Stroke. 2000;31:1081–1089.	171	10.7
94	Detre JA, Alsop DC. Perfusion magnetic resonance imaging with continuous arterial spin labeling: Methods and clinical applications in the central nervous system. Eur J Radiol. 1999;30:115–124.	169	9.9
95	Lev MH, Farkas J, Rodriguez VR, Schwamm LH, Hunter GJ, Putman CM, et al. CT angiography in the rapid triage of patients with hyperacute stroke to intraarterial thrombolysis: Accuracy in the detection of large vessel thrombus. J Comput Assisted Tomogr. 2001;25:520–528.	168	11.2
96	Pineiro R, Pendlebury S, Johansen-Berg H, Matthews PM. Functional MRI detects posterior shifts in primary sensorimotor cortex activation after stroke: Evidence of local adaptive reorganization? Stroke. 2001;32:1134–1139.	166	11.1
97	Wintermark M, Fischbein NJ, Smith WS, Ko NU, Quist M, Dillon WP. Accuracy of dynamic perfusion CT with deconvolution in detecting acute hemispheric stroke. Am J Neuroradiol. 2005;26:104–112.	164	14.9
98	Murphy BD, Fox AJ, Lee DH, Sahlas DJ, Black SE, Hogan MJ, et al. Identification of penumbra and infarct in acute ischemic stroke using computed tomography perfusion-derived blood flow and blood volume measurements. Stroke. 2006;37:1771–1777.	164	16.4
99	Schramm P, Schellinger PD, Fiebach JB, Heiland S, Jansen O, Knauth M, et al. Comparison of CT and CT angiography source images with diffusion-weighted imaging in patients with acute stroke within 6 hours after onset. Stroke. 2002;33:2426–2432.	161	11.5
100	Schramm P, Schellinger PD, Fiebach JB, Heiland S, Jansen O, Knauth M, et al. Comparison of CT and CT angiography source images with diffusion-weighted imaging in patients with acute stroke within 6 hours after onset. Stroke. 2002;33:2426–2432.	159	12.2

Table 2
Top-contributing authors to the list of 100 most-cited articles in stroke imaging

Rank	Author	Number of Publications
1	Hacke, W.	10
2	Koroshetz, W.J.	10
3	Schellinger, P.D.	10
4	Warach, S.	10
5	Fiebach, J.B.	9
6	Sartor, K.	9
7	Schwamm, L.H.	9
8	Buonanno, F.S.	8
9	Gonzalez, R.G.	8
10	Sorensen, A.G.	8
11	Edelman, R.R.	7
12	Wintermark, M.	7

Table 3
Journals that contributed 2 or more articles to the 100 most-cited articles in stroke imaging

Rank	Journal	Journal impact factor (2015)	Number of publications
1	Stroke	5.787	40
2	American Journal of Neuroradiology	3.124	12
3	Annals of Neurology	9.638	12
4	Radiology	6.798	11
5	Neurology	8.166	5
6	Brain	10.103	3

matter lesion studies, basic science research, and studies using animal models or phantoms.

The articles included in the bibliometric analyses were compiled and analyzed using the methods of Lim et al.[9] The database included: Article Title, Scopus Citations, Year of Publication, Journal, Journal Impact Factor, Authors, Number of Institutions, Country of Origin, Study Topic, Study Design, and Sample Size.

Results

Table 1 lists the 100 most-cited stroke-imaging articles.

Most Common Authors and Number of Authors

The total number of authors for the 100 most-cited articles was 156. Table 2 lists the top-contributing authors with a minimum of 8 articles on the top 100 list.

Journals

A total of 18 journals published the 100 most-cited articles. The journals that contributed 3 or more articles are listed in Table 3.

Number of Institutions

Most publications were multi-institutional ($n = 55$). Two of these had 12 institutional affiliations each: a 2015 article by Campbell et al, "Endovascular therapy for ischemic stroke with

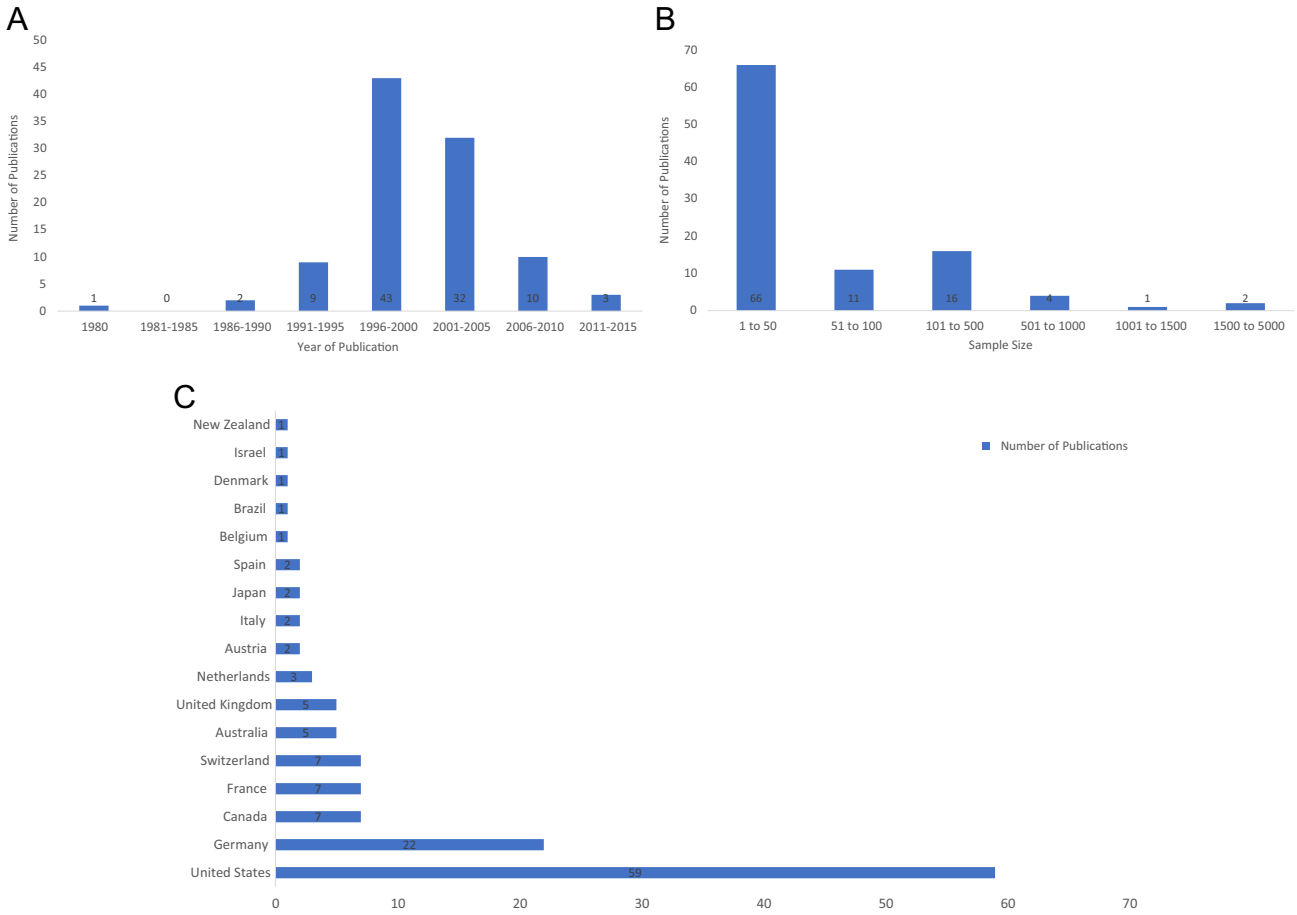

Fig. 1. (A) Distribution of the number of publications of the 100 most-cited articles by 5-year span. (B) Sample size distribution of the 100 most-cited articles. (C) Countries of origin of the 100 most-cited articles. (Color version of the figure available online.)

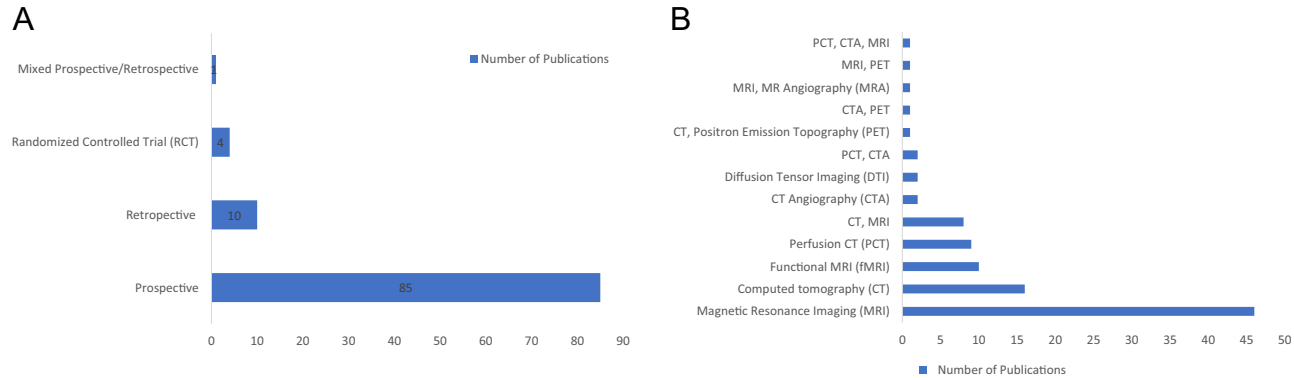

Fig. 2. (A) Frequency of study designs of the 100 most-cited articles. (B) Distribution of imaging modalities of the 100 most-cited articles. (Color version of the figure available online.)

Table 4
Topic distribution of the 100 most-cited articles in stroke imaging

Topic	Number of publications
Prognostic utility of imaging modality	27
Comparison of imaging modalities	23
Other	13
Diagnostic accuracy	10
Stroke recovery	10
Sensitivity/specificity	6
Stroke risk	5
Imaging technique	4
Therapeutic efficacy	2

perfusion-imaging selection" in *New England Journal of Medicine*, and a 2001 article by Patel et al, "Lack of clinical significance of early ischemic changes on computed tomography in acute stroke" in *Journal of the American Medical Association* with 72 and 14 number of authors, respectively. The remaining 45 publications were associated with a single institution.

Year of Publication

These articles were published between 1980 and 2015. Figure 1A represents the distribution of the number of publications of most-cited articles by 5-year span.

Sample Size

The sample size distribution of the top 100 articles is shown in Figure 1B.

Country of Origin

The countries of origin of the 100 most-cited articles are summarized in Figure 1C.

Study Designs and Modalities

The frequency of study design types is shown in Figure 2A. The distribution of imaging modalities is shown in Figure 2B.

Topics

Each article was evaluated for its primary topic. The topic distribution is shown in Table 4.

Discussion

From our database of 100 most-cited stroke imaging articles, the most-cited article ($n = 810$) is a 1995 article by Warach et al, "Acute human stroke studied by whole brain echo planar diffusion-weighted magnetic resonance imaging" in *Annals of Neurology* (Table 1). The article with the greatest average number of citations per year ($n = 516$) is a 2015 article by Campbell et al, "Endovascular therapy for ischemic stroke with perfusion-imaging selection" in *New England Journal of Medicine* (Table 1).

The majority of most-cited stroke imaging studies focused on prognostic utility of imaging modality, followed by comparison of imaging modalities. The most frequent imaging modality was MRI, followed by CT and functional MRI.

Fifty-nine of the top 100 articles came from the United States of America. Forty articles were published in *Stroke*, 12 in *The American Journal of Neuroradiology* and 12 in *Annals of Neurology*. The fact that 2 of the top 3 journals are not specific to radiology demonstrates the importance of imaging to other fields. Most of these papers ($n = 43$) were published between 1996 and 2000.

In summary, we identified and analyzed the 100 most-cited articles within the field of stroke imaging, thereby identifying current research trends and the characteristics of highly cited articles.

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