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Scientific literature addressing detection of monosialoganglioside

A 10-year bibliometric analysis☆

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Abstract

OBJECTIVE: The study was undertaken to explore a bibliometric approach to quantitatively assess the research on detection of monosialoganglioside from 2002 to 2011.

DATA RETRIEVAL: A bibliometric analysis based on the publications on Web of Science was performed using key words such as “monosialoganglioside”, “colloidal gold”, “high performance liquid chromatography” and “detection”.

SELECTION CRITERIA: (1) Research articles on the detection of monosialoganglioside; (2) researches on human and animal fundamentals, clinical trials and case reports; (3) article types: article, review, proceedings paper, note, letter, editorial material, discussion, book chapter; (4) Publication year: 2002–2011. Exclusion criteria: (1) unrelated articles; (2) type of articles: correction; (3) articles from following databases: all databases related to social science and arts & humanities in Web of Science were excluded.

MAIN OUTCOME MEASURES: (1) distribution of subject areas; (2) number of publications annually; (3) document type and language of publications; (4) distribution of institutions; (5) distribution of output in journals; (6) the number of countries in which the article is published; (7) top cited paper.

RESULTS: Overall population stands at 1 880 research articles addressing detection of monosialoganglioside in Web of Science during the study period. Articles (1 599) were the most frequently used document type comprising 85.05%, followed by meeting abstracts, reviews and proceedings papers. The distribution of subject categories showed that monosialoganglioside research covered both clinical and basic science research. The USA, Japan, and Italy were the three most productive countries, and the publication numbers in the USA were highest with 559 papers. The University of Milan, Nagoya University, and Kinki University are the most productive institutions regarding detection of monosialoganglioside. In 559 articles published by Americans, Medical College of Georgia ranked the first with 30 articles, followed by University of Medicine and Dentistry of New Jersey (28 articles), Cornell University (24 articles) and Johns Hopkins University (24 articles). In 442 articles published by Japanese, Nagoya University ranked the first with 40 articles, followed by Kinki University (36 articles), and Dokkyo University (31 articles). Though the total number of publications by Japanese is smaller than Americans, the top three institutions published more publications than American institutions. There is a markedly increase in the number of publications on the subject detection of monosialoganglioside in 2004, which the peak in the past 10 years. The valley bottom of the subject appeared in 2005. In total, the research is increased with time prolonged. *Journal of Neurochemistry, Journal of Biological Chemistry* and *Journal of Neuroimmunology* were core subject journals in monosialoganglioside studies.

CONCLUSION: This study highlights the topics in detection of monosialoganglioside research that are being published around the world.

Key Words: monosialoganglioside; colloidal gold; high performance liquid chromatography; bibliometrics; Web of Science; scientific literature

Abbreviations: GM1, monosialoganglioside; SCI-E, Science Citation Index Expanded; TLC, thin-layer chromatography

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INTRODUCTION

Monosialogangliosides (GM1), sialic-acid-containing glycosphingolipids, are involved in numerous biological processes and closely related to cell-cell recognition, adhesion and signal conduction, and play essential roles in severe pathologies, with predilection in those of the central nervous system. GM1 is mainly composed of ceramide and oligosaccharide chains, and it is the only ganglioside that can permeate the blood-brain barrier. It was first reported by Klenk in 1935 from the brain of a patient diagnosed as having had infantile amaurotic idiocy (Tay-Sachs disease) combined with Niemann-Pick disease[1]. He identified this glycolipid as the storage material typically found in Tay-Sachs disease[2]. He also isolated this lipid from normal human brain, and named it ganglioside because of its glycolipid character and its occurrence in ganglion cells[3]. In 1951, the presence of sialic acid at the surface of cell membranes was first demonstrated by Yamakawa *et al* [4]. He isolated a sialic acid-containing substance from 100 g of freeze-dried ghosts obtained from 10 L of packed horse erythrocytes and named the glycolipid "hematoside", which has the structure of ceramide (1←1β)GLc(4←1β)Gal(3←2α)[4-5]. Sialic acid is the main ingredients for GM1, which participates in the process of cell growth and differentiation[6]. The pre-column derivatizing method[7] and Hypersil NH2 analyzing method[8] have been used in GM1 analysis. However, both of methods are hard to use for complex procedure, large cost or short lifecycle. Ganglioside composition and quantity in different matrices as well as their distribution and expression at the cell surface have been demonstrated by thin-layer chromatography (TLC) as well as immunochemical and immunohistochemical methods[9]. Because of their detection principles and reduced sensitivity, these methods that are based on comparisons, typically provide information on the major components present in the mixture and less or at all on the minor species known to be of biomarker value. Colorimetric method can only determine the total contents of GM1[10-11], as to high performance liquid chromatography, with poor specificity, cannot control the free sialic acid and GM1 quality effectively in clinical application[12]. Recent studies have shown that colloidal gold can be used in GM1 detection[13], but the detailed mechanism still needs to be investigated.

The bibliometric approach is used for information science and to quantitatively analyze numbers of publications in the library, recently, it was introduced to scientific field to guide studying certain subject study from the distribution patterns of the authorship, publication metrics, and citations of literatures, and to investigate research trends in certain field. This study is designed to compare different detection methods for GM1 from published research papers found on Web of Science from 2002 to 2011.

DATA SOURCES AND METHODOLOGY

Design

Bibliometric study.

Time and setting

The study was performed at the Medical College of Hebei University of Engineering on February 18, 2012.

Data retrieval

The search was primarily undertaken from the online version of the Science Citation Index Expanded (SCI-E, 1899–present), accessed *via* Web of Science, Philadelphia, PA, USA. According to Thomson Reuters, SCI-E indexed 8 436 major journals with citation references across 173 scientific disciplines in 2011. SCI-E is considered as one of the most comprehensive and relevant coverage of bibliometric information and journals, which enables researchers to find data, to analyze trends, cross referencing journals and researchers.

The Web of Science containing following databases: SCI-E --1899–present; Conference Proceedings Citation Index-Science (CPCI-S) --1991–present; Book Citation Index-Science (BKCI-S) --2005–present. Social Sciences Citation Index (SSCI) --1898–present; Arts & Humanities Citation Index (A&HCI) --1975–present; Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH) --1991–present; Book Citation Index–Social Sciences & Humanities (BKCI-SSH) --2005–present; Current Chemical Reactions (CCR-EXPANDED) --1985–present; Index Chemicus (IC) --1993–present.

In this paper, Web of Science was searched to determine the number of articles published on GM1 detection.

Inclusive criteria

(1) Articles studied on the GM1 detection.

(2) Type of articles includes articles, reviews, proceedings paper, notes, letter, editorial material, discussion and book chapters.

(3) Year of publication: 2002-2011.

(4) Citation databases: SCI-E --1899–present; Conference Proceedings Citation Index-Science (CPCI-S) --1991–present; Book Citation Index-Science (BKCI-S) --2005–present.

Exclusive criteria

(1) Articles related to other types of ganglioside rather than GM1.

(2) Type of articles: correction.

The advanced query formulation used for GM1 detection

(ts=GM1 not ts=gangliosidosis) or ts=monosialoganglioside or ts=Ganglioside not (ts=Gangliosidosis or ts=trisialo-ganglioside or ts=disialo-ganglioside or ts=GDl or ts=GD2 or ts=GD3 or ts=GT or ts=GQ1b) and ts=(detection or colloidal gold or high performance liquid chromatography or HPLC).

The analysis combined Web of Science data and

statistic functions in Microsoft Excel. The outcomes of all articles referring to GM1 detection were selected and analyzed using the following measurements: (1) distribution of subject areas; (2) number of publications annually; (3) document type and language of publications; (4) distribution of institutions; (5) distribution of output in journals; (6) the number of countries in which the article is published; (7) top cited paper.

RESULTS

Distribution of subject areas of GM1 detection included in Web of Science during 2002 and 2011

Based on the classification of subject areas on Web of Science, the article output data was grouped into 250 subject categories. The articles of the top 10 related subject categories in the research were analyzed in Table 1.

Table 1 Publication output of monosialoganglioside detection in the top 10 subject categories from 2002 to 2011

Rank	Subject category	No. of papers	% of total publication
1	Biochemistry molecular biology	520	27.66
2	Neurosciences	394	20.96
3	Clinical neurology	269	14.31
4	Immunology	229	12.18
5	Cell biology	173	9.20
6	Biophysics	162	8.62
7	Pharmacology pharmacy	80	4.26
8	Chemistry physical	76	4.04
9	Microbiology	71	3.78
10	Chemistry multidisciplinary	62	3.30

From Table 1, the distribution of subject categories showed that most studies on GM1 detection were related to the biochemistry molecular biology and neurosciences. Moreover, Immunology and cell biology were found in the top five subject categories.

Annual publication output on GM1 detection in Web of Science between 2002 and 2011 (Figure 1)

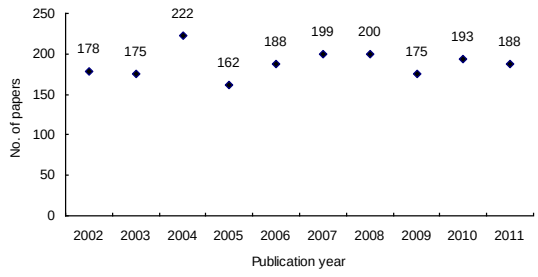

Figure 1 The distribution of annual publication output of monosialoganglioside detection.

The publication on GM1 detection keeps stable between 2002 and 2011. The publication on GM1 detection reached a peak in 2004. However, there are a number of years which saw slightly drops in the number of paper published during 2005 and 2009.

Document type and language of publications in Web of Science between 2002 and 2011

The distribution of document types identified by the SCI-E was analyzed. Eight document types were found in 1 880 publications from 2002 to 2011. Articles (1 599, 85.05%) were the most frequently used document type, followed by meeting abstracts (115; 6.12%), and reviews (112; 5.96%). The correction was excluded from the analysis due to less academic significance (Table 2).

Table 2 Main document type of publication output of monosialoganglioside detection from 2002 to 2011

Document type	No. of papers	% of total publication
Article	1 599	85.05
Meeting abstract	115	6.12
Review	112	5.96
Proceedings paper	74	3.94
Editorial material	20	1.06
Letter	14	0.75
Correction	2	0.11
Book chapter	1	0.05

Ninety-seven percent of all these journal articles were published in English. Articles were also published in French (17; 0.90%), German (8; 0.43%), Unspecified (7; 0.37%), Russian (6; 0.32%), Spanish (4; 0.21%), Japanese (4; 0.21%), Czech (1; 0.05%). Garfield *et al* [14] reported that English is the main language of microbiology research, accounting for 90–95% of all the SCI papers. English remains the dominant language as it is the main language in many fields[15-16]. This is expected because most of the journals listed in the ISI are published in English[17].

Distribution of institutions of GM1 detection included in Web of Science during 2002 and 2011 (Table 3)

Table 3 Distribution of top 10 institutions publishing articles referring to monosialoganglioside from 2002 to 2011

Rank	Institution	Country	No. of papers	% of total publication
1	University of Milan	Italy	53	2.82
2	Nagoya University	Japan	40	2.13
3	Kinki University	Japan	36	1.92
4	Dokkyo University	Japan	31	1.65
5	Russian Academy of Sciences	Russia	31	1.65
6	Chiba University	Japan	30	1.60
7	Kyoto University	Japan	30	1.60
8	Medical College of Georgia	United States	30	1.60
9	National Research Council Canada	Canada	30	1.60
10	University of Medicine and Dentistry of New Jersey	United States	28	1.49

The distribution of institutions for most studies on GM1 detection was Japan and United States. It is interesting that, though USA published 29.73% of articles on GM1 detection, the top one institution is in Italy and the tops two to four institutions are in Japan.

The top three cited papers published by University of Milan are as follows:

Authors: Sonnino S, Mauri L, Chigorno V, *et al*. Source journal: *Glycobiology*. Publication year: 2007. Title: Gangliosides as components of lipid membrane domains[18]. Total citations: 73. Average annual citations: 12.17.

Authors: Terraneo G, Potenza D, Canales A, *et al.* Source journal: *Journal of the American Chemical Society*. Publication year: 2007. Title: A simple model system for the study of carbohydrate-aromatic interactions[19]. Total citations: 54. Average annual citations: 9.00.

Authors: Papini N, Anastasia L, Tringali C, *et al.* Source journal: *Journal of Biological Chemistry*. Publication year: 2004. Title: The plasma membrane-associated sialidase MmNEU3 modifies the ganglioside pattern of adjacent cells supporting its involvement in cell-to-cell interactions[20]. Total citations: 61. Average annual citations: 6.78.

Distribution of output in journals of GM1 detection included in Web of Science during 2002 and 2011 (Table 4)

Table 4 Top 11 journals were selected based on the number of publications on the monosialoganglioside detection between 2002 and 2011

Rank	Source journal	Impact factor	Country	No. of papers
1	*Journal of Neurochemistry*	4.337	England	60
2	*Journal of Biological Chemistry*	5.328	United States	55
3	*Journal of Neuroimmunology*	2.901	Netherlands	36
4	*Journal of Immunology*	5.745	United States	34
5	*Neurology*	8.017	United States	29
6	*Journal of the Peripheral Nervous System*	3.032	United States	26
7	*Biophysical Journal*	4.218	United States	25
7	*Neurochemical Research*	2.608	United States	25
8	*Biochemical and Biophysical Research Communications*	2.595	United States	24
8	*Biochimica ET Biophysica Acta- Biomembranes*	4.647	Netherlands	24
8	*Glycoconjugate Journal*	2.700	Netherlands	24

Research on GM1 detection mainly published in the following journals indexed in Web of Science, including *Journal of Neurochemistry*, *Journal of Biological Chemistry*, *Journal of Neuroimmunology*, *Journal of Immunology* and *Neurology*. Most of source journals are published by Americans.

Distribution of output in countries of GM1 detection included in Web of Science during 2002 and 2011 (Table 5)

Table 5 Top 10 countries of publication output in monosialoganglioside detection between 2002 and 2011

Rank	Country	No. of papers	% of total publication
1	USA	559	29.73
2	Japan	422	22.45
3	Italy	136	7.23
4	Germany	128	6.81
5	France	106	5.64
6	Canada	98	5.21
7	England	91	4.84
8	China	77	4.10
9	Netherlands	67	3.56
10	South Korea	49	2.61
10	Sweden	49	2.61

USA, Japan and Italy are the three countries with the highest outputs in terms of total number published in GM1 detection studies in the past ten years. China, with 77 publications, ranked No. eight in top 10 countries. The comparison of publications among USA, Japan, Italy and China are shown in Figure 2.

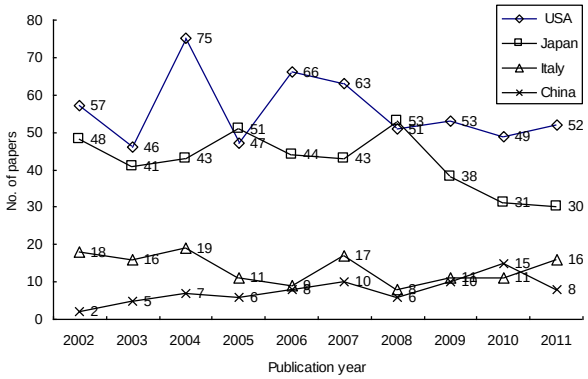

Figure 2 Comparison of publications on monosialoganglioside detection among USA, Japan, Italy and China.

The USA published most papers on GM1 detection, and the American institution and source of journals are shown in Figures 3, 4.

In 559 articles published by Americans, Medical College of Georgia ranked the first with 30 articles, followed by University of Medicine and Dentistry of New Jersey (28 articles), Cornell University (24 articles) and Johns Hopkins University (24 articles).

The top five cited papers published by Medical College of Georgia are as follows:

Authors: Ravina BM, Fagan SC, Hart RG, *et al.* Source journal: *Neurology*. Publication year: 2003. Title: Neuroprotective agents for clinical trials in Parkinson's disease - A systematic assessment[21]. Total citations: 152. Average annual citations: 15.20.

Authors: Birklé S, Zeng G, Gao L, *et al.* Source journal: *Biochimie*. Publication year: 2003. Title: Role of tumor-associated gangliosides in cancer progression[22].

Total citations: 82. Average annual citations: 8.20.
Authors: Ariga T, McDonald MP, Yu RK. Source journal: *Journal of Lipid Research*. Publication year: 2008. Title: Role of ganglioside metabolism in the pathogenesis of Alzheimer's disease - a review[23]. Total citations: 64. Average annual citations: 12.80.
Authors: Ngamukote S, Yanagisawa M, Ariga T, *et al.* Source journal: *Journal of Neurochemistry*. Publication year: 2007. Title: Developmental changes of glycosphingolipids and expression of glycogenes in mouse brains[24]. Total citations: 43. Average annual citations: 7.17.
Authors: Kaida K, Ariga T, Yu RK. Source journal: *Glycobiology*. Publication year: 2009. Title: Antiganglioside antibodies and their pathophysiological effects on Guillain-Barre syndrome and related disorders-A review[25]. Total citations: 23. Average annual citations: 5.75.

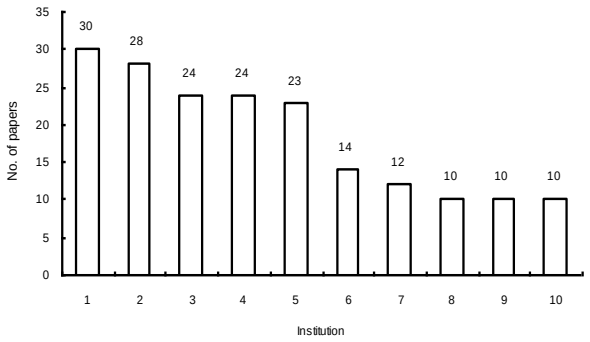

Figure 3 American institutions that published ≥ 10 articles on monosialoganglioside detection in the past 10 years.

1: Medical College of Georgia.

2: University of Medicine and Dentistry of New Jersey.

3: Cornell University.

4: Johns Hopkins University.

5: Harvard University.

6: Ohio State University.

7: University of Washington.

8: Georgetown University.

9: National Cancer Institute.

10: University of Illinois.

The top five cited papers published by University of Medicine and Dentistry of New Jersey are as follows:
Authors: Ledeen RW, Wu G. Source journal: *Neurochemical Research*. Publication year: 2002. Title: Ganglioside function in calcium homeostasis and signaling[26]. Total citations: 52. Average annual citations: 4.73.
Authors: Xie X, Wu G, Lu ZH, *et al.* Source journal: *Journal of Neurochemistry*. Publication year: 2002. Title: Potentiation of a sodium-calcium exchanger in the nuclear envelope by nuclear GM1 ganglioside[27]. Total citations: 49. Average annual citations: 4.45.
Authors: Wang J, Lu ZH, Gabius HJ, *et al.* Source journal: *Journal of Immunology*. Publication year: 2009. Title: Cross-linking of GM1 ganglioside by galectin-1 mediates regulatory T cell activity involving TRPC5 channel activation: possible role in suppressing experimental autoimmune encephalomyelitis[28]. Total citations: 40. Average annual citations: 10.00.
Authors: Wu G, Lu ZH, Wang J, *et al.* Source journal: *Journal of Neuroscience*. Publication year: 2005. Title: Enhanced susceptibility to kainate-induced seizures, neuronal apoptosis, and death in mice lacking gangliotetraose gangliosides: protection with LIGA 20, a membrane-permeant analog of GM1[29]. Total citations: 39. Average annual citations: 4.88.
Authors: Wu G, Lu ZH, Obukhov AG, *et al.* Source journal: *Journal of Neuroscience*. Publication year: 2007. Title: Induction of calcium influx through TRPC5 channels by cross-linking of GM1 ganglioside associated with alpha 5 beta 1 integrin initiates neurite outgrowth[30]. Total citations: 35. Average annual citations: 5.83.

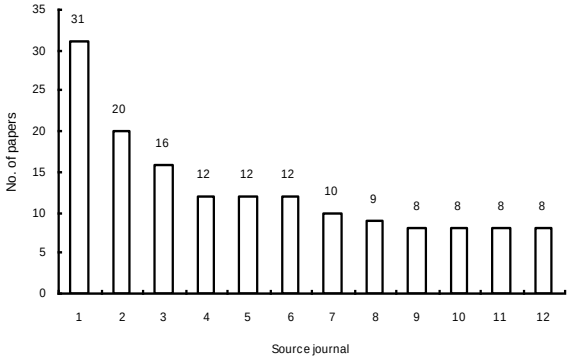

Figure 4 American articles on monosialoganglioside detection mainly published in 12 source journals in the past 10 years.

1: *Journal of Neurochemistry.*

2: *Journal of Biological Chemistry.*

3: *Journal of Immunology*.

4: *Biophysical Journal*.

5: *Brain Research*.

6: *Neurochemical Research*.

7: *Analytical Chemistry*.

8: *Journal of Neuroscience*.

9: *Alcoholism Clinical and Experimental Research*.

10: *Investigative Ophthalmology Visual Science*.

11: *Journal of Neuroimmunology.*

12: *Journal of Neuroscience Research*.

Japan is the second productive country on GM1 detection, and the Japanese institution and source of journals for most Japanese articles are shown in Figures 5, 6.

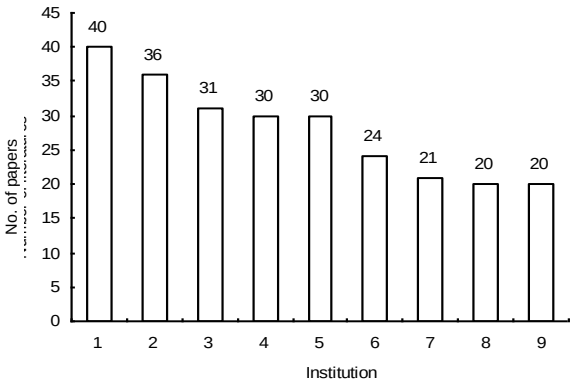

Figure 5 Japanese institution that published ≥ 20 articles on monosialoganglioside detection in the past 10 years.

1: Nagoya University.
2: Kinki University.
3: Dokkyo University.
4: Chiba University.
5: Kyoto University.
6: Dokkyo Medical University.
7: RIKEN.
8: Osaka University.
9: University of Tokyo

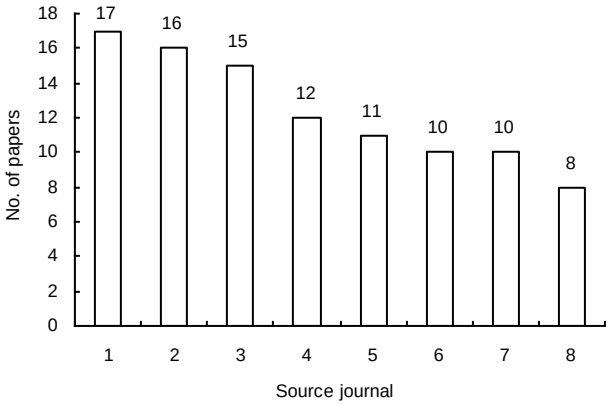

Figure 6 Japanese articles on monosialoganglioside detection mainly published in eight source journals in the past 10 years.

1: *Journal of Neuroimmunology.*
2: *Journal of Neurochemistry.*
3: *Journal of Biological Chemistry.*
4: *Neurology.*
5: *Glycoconjugate Journal.*
6: *Glycobiology.*
7: *Journal of Neurology Neurosurgery and Psychiatry.*
8: *Biochemical and Biophysical Research Communications.*

In 442 articles published by Japanese, Nagoya University ranked the first with 40 articles, followed by Kinki University (36 articles), and Dokkyo University (31 articles). Though the total number of publications by Japanese is smaller than Americans, the top three institutions of Japanese published more publications than American institutions.

Top cited publication on GM1 detection included in Web of Science from 2002 to 2011 (Table 6)

Table 6 Top cited papers on monosialoganglioside detection from 2002 to 2011

Title	Authors	Publication year	Average per year
Glyconanoparticles for the colorimetric detection of cholera toxin[31]	Schofield CL, Field RA, Russell DA.	2007	11.67
Electrochemical immunosensor for cholera toxin using liposomes and poly (3,4-ethylenedioxythiophene)-coated carbon nanotubes[32]	Viswanathan S, Wu LC, Huang MR, *et al*.	2006	11.00
Analysis of gangliosides directly from thin-layer chromatography plates by infrared matrix-assisted laser desorption/ionization orthogonal time-of-flight mass spectrometry with a glycerol matrix[33]	Dreisewerd K, Müthing J, Rohlfing A, *et al*.	2005	9.00
Detection of conserved N-linked glycans and phase-variable lipooligosaccharides and capsules from Campylobacter cells by mass spectrometry and high resolution magic angle spinning NMR spectroscopy[34]	Szymanski CM, Michael FS, Jarrell HC, *et al*.	2003	8.90
Identification of 41g-B7-H3 as a neuroblastoma-associated molecule that exerts a protective role from an NK cell-mediated lysis[35]	Castriconi R, Dondero A, Augugliaro R, *et al*.	2004	7.44
Regenerable tethered bilayer lipid membrane arrays for multiplexed label-free analysis of lipid-protein interactions on poly(dimethylsiloxane) microchips using SPR imaging[36]	Taylor JD, Linman MJ, Wilkop T, *et al*.	2009	7.25
A liposome-PCR assay for the ultrasensitive detection of biological toxins[37]	Mason JT, Xu L, Sheng ZM, *et al*.	2006	7.14
MALDI mass spectrometry imaging of gangliosides in mouse brain using ionic liquid matrix[38]	Chan K, Lanthier P, Liu X, *et al*.	2009	7.00
Determination of cellular lipids bound to human CD1d molecules[39]	Cox D, Fox L, Tian R, Bardet W, *et al*.	2009	6.50
High-sensitivity analysis of glycosphingolipids by matrix-assisted laser desorption/ionization quadrupole ion trap time-of-flight imaging mass spectrometry on transfer membranes[40]	Goto-Inoue N, Hayasaka T, Sugiura Y, *et al*.	2008	6.00

DISCUSSION

Gangliosides are structural components of biologic

membranes. However, compared with glycoproteins within the intricate carbohydrate network that constitutes the glycocalyx surrounding living cells, gangliosides represent minor constituents in quantization. Ganglioside metabolites have become recognized for their participation in membrane functions and signaling events that control a wide array of cellular activities. Cer and sphingosine-1-phosphate, two major ganglioside metabolites, are involved in signaling pathways that regulate cell proliferation, apoptosis, motility, differentiation, stress responses, protein synthesis, carbohydrate metabolism, innate and adaptive immunity, and angiogenesis[41].

In the past years, modern MS instrumentation, which is characterized by sensitivity, resolution, and high accuracy, has to be gradually introduced in the field of glycolipidomics[42-44]. The majority of ganglioside extracts exhibit a high heterogeneity, which requires separation prior to MS analysis, TLC followed by MS screening of individual TLC bands/fractions was initially established as a protocol for handling, to some extent, the problem of sample complexity[45-46]. More recently, separation methods hyphenated to MS demonstrated the capability to offer, at high sensitivity, data on major and minor ganglioside components in mixtures and help in understanding previously unknown structural characteristics.

Bibliometrics is a set of methods used to study or measure texts and information[47]. Based on our bibliometric results, we showed the following research trends in the GM1 detection.

Based on the bibliometric analysis, the following comparison and results can be made among GM1 detection research.

First, there are 1 880 research articles addressing GM1 detection included in Web of Science from 2002 to 2011. The research on GM1 detection is attracting an ever increasing attention among the global researchers in the 2004 of the 21st century, notwithstanding the large drops in outputs in 2005 and 2009.

Second, subject categories, including biochemistry molecular biology, neurosciences, clinical neurology, immunology and cell biology are involved in the GM1 field. Because of this broad range, scholars and surgeons in these subjects work hard and readily publish articles on GM1.

Last but not the least, the journals focusing in neurochemistry published most articles in GM1 detection, the USA has the highest total number of publications and citations.

Top cited paper does not necessarily equal to the highest impact paper on an annual basis. The immediate impact in the year when they were published is indicated by the average citation per annum or the citation during each year.

Author contributions: Yanli Xu retrieved the references, extracted the data, conceived and designed the study, and wrote the manuscript. Miaojing Li, Zhijun Liu, Aiping Xi, Chaoxian Zhao retrieved the references, extracted the data, and conceived and designed the study. Jianzhong Zhang contributed to the review, conception and design, paper revision, and study instruction.

Conflicts of interest: None declared.

REFERENCES

[1] Klenk E. Über die Natur der Phophatide und anderer lipoide des Gehirns und der Leber bei der Niemann-Pickschen Krankheit. Z Phys Chem. 1935;235:24-36.
[2] Klenk E. Beitrdge zur Chemie der Lipiodosen. Z Phys Chem. 1939;262:128.
[3] Klenk E. Uber die Ganglioside des Gehirns bei der infantlen amaurotischen Idiotie von Typus Tay-Sachs. Ber Dt Chem Ges. 1942;75:1632.
[4] Yamakawa T, Suzuki S. The chemistry of the lipids of posthemolytic residue or stroma of erythrocytes. I. Concerning the ether-insoluble lipids of lyophilized horse blood stroma. J Biochem. 1951;38:199-212.
[5] Yamakawa T. Studies on erythrocyte glycolipids. Proc Jpn Acad Ser B. 2005;81:52-63.
[6] Hannun YA. The sphingomyelin cycle and the second messenger function of ceramide. J Biol Chem. 1994;269(5):3125-3128.
[7] Ullman MD, McCluer RH. Quantitative analysis of brain gangliosides by high performance liquid chromatography of their perbenzoyl derivatives. J Lipid Res. 1985;26(4):501-506.
[8] Wagener R, Röhn G, Schillinger G, et al. Ganglioside profiles in human gliomas: quantification by microbore high performance liquid chromatography and correlation to histomorphology and grading. Acta Neurochir (Wien). 1999;141(12):1339-1345.
[9] Pan XL, Hua TY, Wu YY, et al. Detection of gangliosides in human milk with a high performance thin layer chromatography (HPTLC). Zhonghua Yufang Yixue Zazhi. 2001;35(2):111-113.
[10] Pan Y, Huang RB, Wang ZS, et al. Determination and analysis of brain gangliosides in pigs. Shengwu Huaxue yu Shengwu Wuli Jinzhan. 1994;21(4):353-355.
[11] Wang TR, Xu AG, Li LJ, et al. Values of determining serum gangliosides in patients with entero-system diseases. Sichuan Yixue. 2008;29(12):1705-1707.
[12] Mattoo RL, Roseman S. Quantitative determination of sialic acid in the monosialoganglioside, GM1, by the thiobarbituric acid method. Anal Biochem. 1997;246(1):30-33.
[13] Wilson RL, Frisz JF, Hanafin WP, et al. Fluorinated colloidal gold immunolabels for imaging select proteins in parallel with lipids using high-resolution secondary ion mass spectrometry. Bioconjug Chem. 2012;23(3):450-460.
[14] Garfield E, Welljamsdorof A. The microbiology literature: languages of publication and their relative citation impact. FEMS Microbiol Lett. 1992;100:33-37.
[15] Hsieh WH, Chiu WT, Lee YS, et al. Bibliometric analysis of patent ductus arteriosus treatments. Scientometrics. 2004;60:205-215.
[16] Chen SR, Chiu WT, Ho YS. Asthma in children: mapping the literature by bibliometric analysis. Rev Fr Allergol Immunol Clin. 2005;45:442-446.
[17] Chiu WT, Ho YS. Bibliometric analysis of tsunami research. Scientometrics. 2007;73:3-17.
[18] Sonnino S, Mauri L, Chigorno V, et al. Gangliosides as components of lipid membrane domains. Glycobiology. 2007;17(1):1R-13R.
[19] Terraneo G, Potenza D, Canales A, et al. A simple model system for the study of carbohydrate-aromatic interactions. J Am Chem Soc. 2007;129(10):2890-2900.
[20] Papini N, Anastasia L, Tringali C, et al. The plasma membrane-associated sialidase MmNEU3 modifies the ganglioside pattern of adjacent cells supporting its involvement in cell-to-cell interactions. J Biol Chem. 2004;279(17):16989-16995.

[21] Ravina BM, Fagan SC, Hart RG, et al. Neuroprotective agents for clinical trials in Parkinson's disease: a systematic assessment. Neurology. 2003;60(8):1234-1240.
[22] Birklé S, Zeng G, Gao L, et al. Role of tumor-associated gangliosides in cancer progression. Biochimie. 2003;85(3-4):455-463.
[23] Ariga T, McDonald MP, Yu RK. Role of ganglioside metabolism in the pathogenesis of Alzheimer's disease--a review. J Lipid Res. 2008;49(6):1157-1175.
[24] Ngamukote S, Yanagisawa M, Ariga T, et al. Developmental changes of glycosphingolipids and expression of glycogenes in mouse brains. J Neurochem. 2007;103(6):2327-2341.
[25] Kaida K, Ariga T, Yu RK. Antiganglioside antibodies and their pathophysiological effects on Guillain-Barré syndrome and related disorders--a review. Glycobiology. 2009;19(7):676-692.
[26] Ledeen RW, Wu G. Ganglioside function in calcium homeostasis and signaling. Neurochem Res. 2002;27(7-8):637-647.
[27] Xie X, Wu G, Lu ZH, et al. Potentiation of a sodium-calcium exchanger in the nuclear envelope by nuclear GM1 ganglioside. J Neurochem. 2002;81(6):1185-1195.
[28] Wang J, Lu ZH, Gabius HJ, et al. Cross-linking of GM1 ganglioside by galectin-1 mediates regulatory T cell activity involving TRPC5 channel activation: possible role in suppressing experimental autoimmune encephalomyelitis. J Immunol. 2009; 182(7):4036-4045.
[29] Wu G, Lu ZH, Wang J, et al. Enhanced susceptibility to kainate-induced seizures, neuronal apoptosis, and death in mice lacking gangliotetraose gangliosides: protection with LIGA 20, a membrane-permeant analog of GM1. J Neurosci. 2005;25(47): 11014-11022.
[30] Wu G, Lu ZH, Obukhov AG, et al. Induction of calcium influx through TRPC5 channels by cross-linking of GM1 ganglioside associated with alpha5beta1 integrin initiates neurite outgrowth. J Neurosci. 2007;27(28):7447-7458.
[31] Schofield CL, Field RA, Russell DA. Glyconanoparticles for the colorimetric detection of cholera toxin. Anal Chem. 2007;79(4): 1356-1361.
[32] Viswanathan S, Wu LC, Huang MR, et al. Electrochemical immunosensor for cholera toxin using liposomes and poly(3,4-ethylenedioxythiophene)-coated carbon nanotubes. Anal Chem. 200615;78(4):1115-1121.
[33] Dreisewerd K, Müthing J, Rohlfing A, et al. Dreisewerd K, Müthing J, Rohlfing A, et al. Analysis of gangliosides directly from thin-layer chromatography plates by infrared matrix-assisted laser desorption/ionization orthogonal time-of-flight mass spectrometry with a glycerol matrix. Anal Chem. 2005;77(13):4098-4107.
[34] Szymanski CM, Michael FS, Jarrell HC, et al. Detection of conserved N-linked glycans and phase-variable lipooligosaccharides and capsules from campylobacter cells by mass spectrometry and high resolution magic angle spinning NMR spectroscopy. J Biol Chem. 2003;278(27):24509-24520.
[35] Castriconi R, Dondero A, Augugliaro R, et al. Identification of 4Ig-B7-H3 as a neuroblastoma-associated molecule that exerts a protective role from an NK cell-mediated lysis. Proc Natl Acad Sci U S A. 2004;101(34):12640-126405.
[36] Taylor JD, Linman MJ, Wilkop T, et al. Regenerable tethered bilayer lipid membrane arrays for multiplexed label-free analysis of lipid-protein interactions on poly(dimethylsiloxane) microchips using SPR imaging. Anal Chem. 2009;81(3):1146-1153.
[37] Mason JT, Xu L, Sheng ZM, et al. A liposome-PCR assay for the ultrasensitive detection of biological toxins. Nat Biotechnol. 2006; 24(5):555-557.
[38] Chan K, Lanthier P, Liu X, et al. MALDI mass spectrometry imaging of gangliosides in mouse brain using ionic liquid matrix. Anal Chim Acta. 2009;639(1-2):57-61.
[39] Cox D, Fox L, Tian R, et al. Determination of cellular lipids bound to human CD1d molecules. PLoS One. 2009;4(5): e5325.
[40] Goto-Inoue N, Hayasaka T, Sugiura Y, et al. High-sensitivity analysis of glycosphingolipids by matrix-assisted laser desorption/ionization quadrupole ion trap time-of-flight imaging mass spectrometry on transfer membranes. J Chromatogr B Analyt Technol Biomed Life Sci. 2008;870(1):74-83.
[41] Morales A, Lee H, Goñi FM, et al. Sphingolipids and cell death. Apoptosis. 2007;12(5):923-939.
[42] Vukelić Z, Kalanj-Bognar S, Froesch M, et al. Human gliosarcoma-associated ganglioside composition is complex and distinctive as evidenced by high-performance mass spectrometric determination and structural characterization. Glycobiology. 2007; 17(5):504-515.
[43] Zamfir AD, Vukelic Z, Schneider A, et al. A novel approach for ganglioside structural analysis based on electrospray multiple-stage mass spectrometry. J Biomol Tech. 2007;18(4): 188-193.
[44] Almeida R, Mosoarca C, Chirita M, et al. Coupling of fully automated chip-based electrospray ionization to high-capacity ion trap mass spectrometer for ganglioside analysis. Anal Biochem. 2008;378(1):43-52.
[45] Metelmann W, Vukelić Z, Peter-Katalinić J. Nano-electrospray ionization time-of-flight mass spectrometry of gangliosides from human brain tissue. J Mass Spectrom. 2001;36(1):21-29.
[46] Ivleva VB, Sapp LM, O'Connor PB, et al. Ganglioside analysis by thin-layer chromatography matrix-assisted laser desorption/ionization orthogonal time-of-flight mass spectrometry. J Am Soc Mass Spectrom. 2005;16(9):1552-1560.
[47] Qiu JP, Wang HX. The level analysis of bibliometrics development in the 20th century. Gaoxiao Tushuguan Gongzuo. 2000;20(80): 130.

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