

Global trends of ERCP research in the last 25 years

A bibliometrics study

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Abstract

Purpose: Endoscopic retrograde cholangiopancreatography (ERCP) has been used in clinical practice for over 50 years. This study aims to investigate the current state of research in the field of ERCP.

Methods: Web of Science database was searched using the term “ERCP” for articles published between 1994 and 2018. The total number of articles from the top 20 countries with the most published articles was determined. The top 5 countries were compared in terms of output per capita, number of articles published in top journals, cumulative impact factor (IF), and average IF. All annual data were subjected to time-trend analysis. The frequently used terms in the titles and abstracts of all articles were retrieved to conduct co-occurrence analysis to determine the research focus of ERCP.

Results: A total of 9960 articles on ERCP were published between 1994 and 2018, of which 8778 articles were from the top 20 producing countries. There was a significant positive correlation between the output and GDP of each country ($R = 0.870$, $P = .001$). The United States of America (USA), Japan, Germany, Italy, and China were the top 5 producing countries with 3190 (32.0%), 868 (8.7%), 658 (6.6%), 512 (5.1%) and 488 (4.9%) articles published, respectively. The USA, Japan, Italy, and China were trending upwards in the total outputs and outputs per capita, while Germany were trending downwards. For average IF, Germany had a downwards trend, while the other 4 countries remained stable. Overall, the USA had the highest output per capita (97.5/10 million) and the highest average IF (6.454). China had the lowest output per capita (3.5/10 million) and average IF (3.125). The ERCP procedures for sphincter of Oddi dysfunction, the combination of ERCP, and laparoscopic cholecystectomy have been the research focus of ERCP.

Conclusions: Except for Germany, research on ERCP will continue to increase in the top-producing countries. The outputs per capita and quality of articles from developed countries are higher than those from developing countries.

Abbreviations: ERCP = Endoscopic retrograde cholangiopancreatography, ERCPists = ERCP practitioners, EUS = endoscopic ultrasound, EUS-FNA = EUS-guided fine-needle aspiration, GDP = gross domestic product, IF = impact factor, ISI = the Institute for Scientific Information, JCR = Journal Citation Reports, LC = laparoscopic cholecystectomy, PEP = post-ERCP pancreatitis, SCIE = science citation index expanded, SOD = sphincter of Oddi dysfunction, WOS = Web of Science.

Keywords: chronic pancreatitis, endoscopic retrograde cholangiopancreatography, impact factor, journal citation reports, research, science citation index expanded.

1. Introduction

Endoscopic retrograde cholangiopancreatography (ERCP) is a safe and effective endoscopic procedure for the diagnosis and therapy of many pancreaticobiliary diseases.^[1,2] The first ERCP was performed in 1968 by McCune et al^[3] Until then, diagnoses were made mainly by clinical experience, with basic labs and

plain radiographs being slightly helpful.^[4] Surgical treatment was often delayed because of uncertain diagnosis.

The application of ERCP in clinical practice has enabled visualization of pancreatic and biliary duct drainage systems. Cholelithiasis and obstructive jaundice, strictures at the papilla of Vater, pancreatitis, and tumors of the bile ducts have been all easier to diagnose.^[5] In the early stage of clinical application,

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ERCP had a significant and steady increase worldwide between 1980 and 2000 as a diagnostic tool. However, its dominance was eroded after 2000 due to the emergence of less invasive diagnostic methods, such as computed tomography, magnetic resonance cholangiopancreatography, and endoscopic ultrasound (EUS).^[1,4,6] Fortunately, a series of breakthroughs have made ERCP the primary endoscopic approach for treating pancreatic and biliary diseases.^[1,6] Currently, there are more than 650,000 ERCP procedures per year in the USA alone.^[6] In developing countries, such as China, ERCP also has made great progress. From 2006 to 2012, the number of hospitals in China that can perform ERCP increased from 470 to 1156. The total ERCP volume increased from 63,787 to 195,643, of which > 95% were therapeutic.^[7]

Despite significant growth globally, there are still some ERCP-related issues remain unresolved. In clinical practice, postERCP pancreatitis (PEP) and ERCP-related infections are difficult complications of ERCP.^[1,8] Studies have been conducted to reduce unnecessary ERCP procedures in the classification system of indications for ERCP. For example, the routine use of preoperative ERCP in patients with known or suspected cholangiocarcinoma can relieve jaundice but may increase the incidence of adverse events in some reports.^[6,9,10] To improve the clinical application of ERCP, considerable time and resources have been devoted to related research. Currently, there are no reports on the global research status of ERCP. In this study, articles on ERCP were extracted from international journals to analyze the current state of global research in this field.

2. Materials and Methods

This study was a bibliometrics study which did not involve any clinical trials and patient consent. Therefore, there was no need for approval of ethics committee or institutional review board.

The Science Citation Index Expanded (SCIE) database of Web of Science (WOS) was searched using the term “ERCP” for the number of articles published worldwide from January 1994 to December 2018.^[11] All member states of the United Nations were included.^[12] Then, the “Countries/Regions” category was used to retrieve the total number of articles from each country, and the top 20 countries with the most articles were identified. The number of original articles and reviews from each country were determined. Then, each country’s shares in the total articles, original articles, and reviews were calculated.

To determine the correlation between the number of articles and economic development of the top 20 producing countries, the gross domestic product (GDP) of each country was retrieved to represent the level of economic development.^[13] Correlation analysis was then conducted to assess the relationship between the total number of articles and GDP from each country.

The 5 top producing countries were selected for quantity and quality comparisons. The annual number of articles from these 5 countries was retrieved. The populations of the 5 countries from 1994 to 2018 were extracted from World Bank Open Data,^[14] which were then used to calculate the total and annual number of articles per capita. The number of total articles and articles per capita of the 5 countries were evaluated using time-trend analysis.

Three methods were used to compare the quality of the articles from the top 5 producing countries. First, the top 10 journals with the highest impact factor (IF) were identified (*New England Journal of Medicine*, *the Lancet*, *Nature*, *Lancet Oncology*, *Nature Reviews Disease Primers*, *Journal of Clinical Oncology*, *Nature Genetics*, *Physiological Reviews*, *Cancer Cell*, and *JAMA Oncology*), and the number of publications in the above journals from each of the 5 countries were determined. Second, numbers of each country’s publications in each journal were identified. The IF of each journal was retrieved from the Journal Citation Reports (JCR) 2018.^[15] The cumulative IF of each country was then calculated by summing the IF of all articles. The average IF

was calculated by dividing the cumulative IF by the total number of articles. Third, the citation of each article was added up to retrieve the total citation of articles for each country, and the average citation was calculated in the same way as the average IF.

In addition, the 10 most popular journals were determined according to the number of articles published of each country. To elucidate the current research focus of ERCP, the VOS-viewer (Leiden University, Leiden, the Netherlands) was used to conduct co-occurrence analysis. The keywords (defined as words that were used more than 30 times in titles and abstracts of all publications) were retrieved and 60% of the most relevant keywords were further identified to generate the final co-occurrence map.

Statistical analyses were performed using SPSS 21.0 (IBM SPSS, Inc. Armonk, NY). Regression analysis was used to determine whether there was any significant change in each country’s share, number of articles per capita and average IF over time. The Pearson test was used to determine whether there was a correlation between the number of articles and GDP of each country. A 2-tailed test was used for the significance test, and $P = .05$ was considered significant.

3. Results

3.1. Numbers of total articles, original articles, and reviews

A total of 9960 articles on ERCP published between January 1994 and December 2018 were retrieved from the SCIE database, of which 8778 articles were from the top 20 countries (Fig. 1), accounting for 88.1% of the total (Table 1). Most of the top 20 countries are in Europe, North America, and East Asia. There was a significant positive correlation between the number of articles and GDP of each country ($R = 0.870$, $P.001$, Fig. 2). The USA ranked 1st with 3190 articles, accounting for 32.0% of the total, with an upward trend over time ($P.001$). Japan, Germany, Italy, and China ranked 2nd, 3rd, 4th, and 5th, with 868 (8.7%), 658 (6.6%), 512 (5.1%) and 488 (4.9%) articles, respectively. There were also significant increases for Japan, Italy, and China (all $P.001$), but a downward trend for Germany ($P = .034$, Fig. 3). In terms of original articles, the USA published 1661 articles, accounting for 28.2% of the total. Japan, Germany, China, and Italy ranked 2nd, 3rd, 4th, and 5th, with 623 (10.6%), 509 (8.6%), 358 (6.1%), and 332 (5.6%) articles, respectively. For reviews, the USA, China, Germany, Japan, and Italy ranked 1st, 2nd, 3rd, 5th, and 6th, with 219 (39.0%), 49 (8.7%), 42 (7.5%), 38 (6.8%), and 32 (5.7%) articles, respectively.

3.2. Number of articles per capita

In terms of the number of articles per capita, the USA had the most articles per capita among the 5 countries, with 97.5 articles per 10 million population. The number of articles per capita in Italy, Germany, Japan, and China was 84.8, 79.4, 68.6, and 3.5 respectively. There were significant increases for the USA, Japan, Italy, and China (all $P = .001$), but a downward trend for Germany ($P = .036$, Fig. 4).

3.3. Articles published in top journals

The top 5 producing countries published a total of 25 articles in the top 10 journals with the highest IF (Table 2). The United States ranked first with 17 articles. Japan, Germany, Italy, and China published 0, 5, 2, and 1 articles respectively.

3.4. Cumulative IF, average IF, total citation, and average citation

The USA had the highest cumulative IF (20,588.4), average IF (6.5), and total citations (60,761) among the top 5 countries.

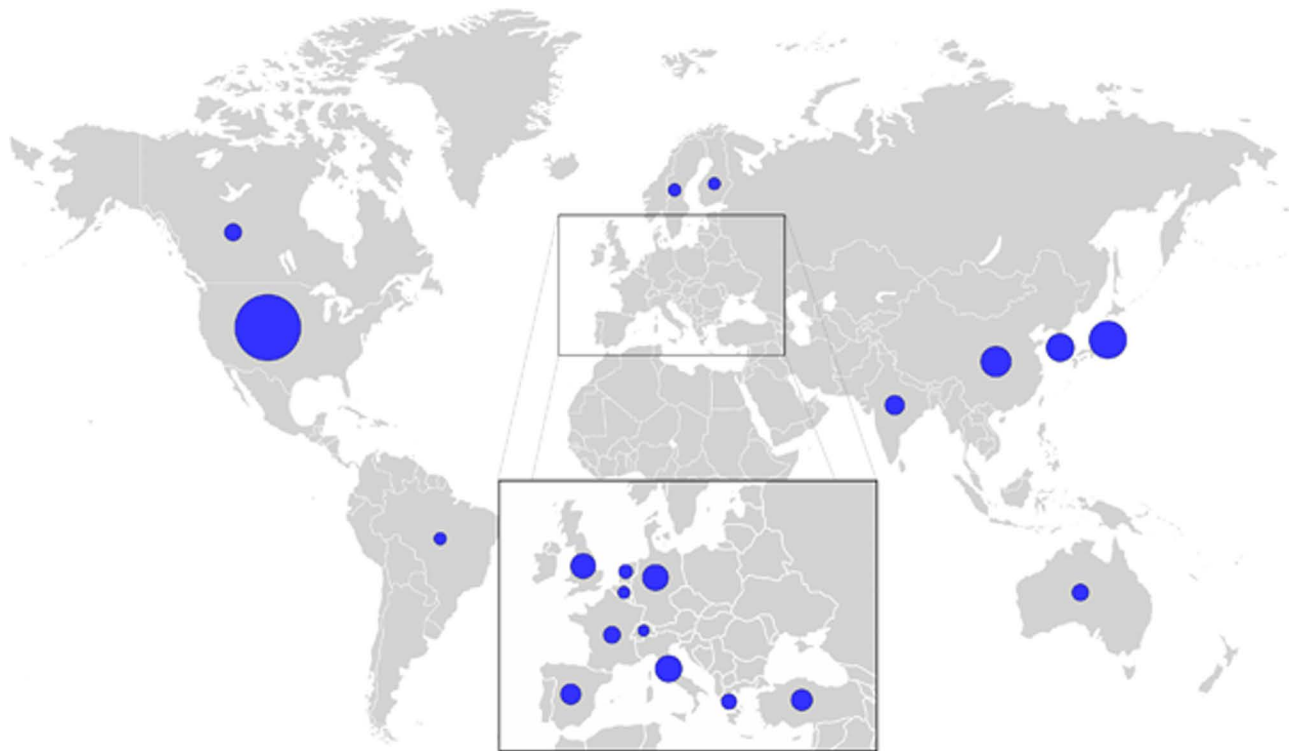


Figure 1. The distribution of 20 highest-output countries. The distribution of blue spots represented the locations of 20 highest-output countries. The area of blue spots represented the outputs of these countries, the larger the spot, the higher the output.

Table 1
Share of articles referring to ERCP for 20 highest-output countries.

Rank	Total Articles (n = 9960)		Original Articles (n = 5885)		Reviews (n = 562)				
	Country	Number	Percentage (%)	Country	Number	Percentage (%)	Country	Number	Percentage (%)
1	USA	3190	32.0	USA	1661	28.2	USA	219	39.0
2	Japan	868	8.7	Japan	623	10.6	China	49	8.7
3	Germany	658	6.6	Germany	509	8.6	Germany	42	7.5
4	Italy	512	5.1	China	358	6.1	UK	39	6.9
5	China	488	4.9	Italy	332	5.6	Japan	38	6.8
6	UK	477	4.8	South Korea	324	5.5	Italy	32	5.7
7	South Korea	426	4.3	UK	234	4.0	France	24	4.3
8	Spain	268	2.7	Turkey	207	3.5	India	24	4.3
9	Turkey	254	2.6	France	182	3.1	Canada	20	3.6
10	France	242	2.4	Spain	168	2.9	Australia	16	2.8
11	India	220	2.2	Canada	136	2.3	Spain	14	2.5
12	Canada	208	2.1	India	133	2.3	Netherlands	13	2.3
13	Australia	168	1.7	Greece	123	2.1	Brazil	12	2.1
14	Greece	148	1.5	Netherlands	108	1.8	Greece	11	2.0
15	Netherlands	144	1.4	Australia	98	1.7	Belgium	10	1.8
16	Belgium	126	1.3	Belgium	95	1.6	Singapore	8	1.4
17	Sweden	101	1.0	Sweden	87	1.5	Turkey	8	1.4
18	Finland	93	0.9	Finland	81	1.4	Austria	7	1.2
19	Brazil	84	0.8	Switzerland	61	1.0	Poland	7	1.2
20	Switzerland	77	0.8	Poland	59	1.0	Hungary	6	1.1

Italy had the highest average number of citations (20.2). China had the lowest cumulative IF (1524.9), average IF (3.1), total citations (4504), and average citations (9.2, Table 3). There was a downward trend in the average IF for Germany ($P = .002$), but no significant trend was observed for the other 4 countries (all $P = .05$, Fig. 5).

3.5. Most popular journals

Gastrointestinal endoscopy (GIE) was the most popular journal in the USA, Japan, and China with 1075, 136, and 51 articles published, respectively. *Endoscopy* was the most popular journal in Germany, with 80 articles published; *Digestive and Liver Disease* was the most popular in Italy, with 69 articles published (Table 4).

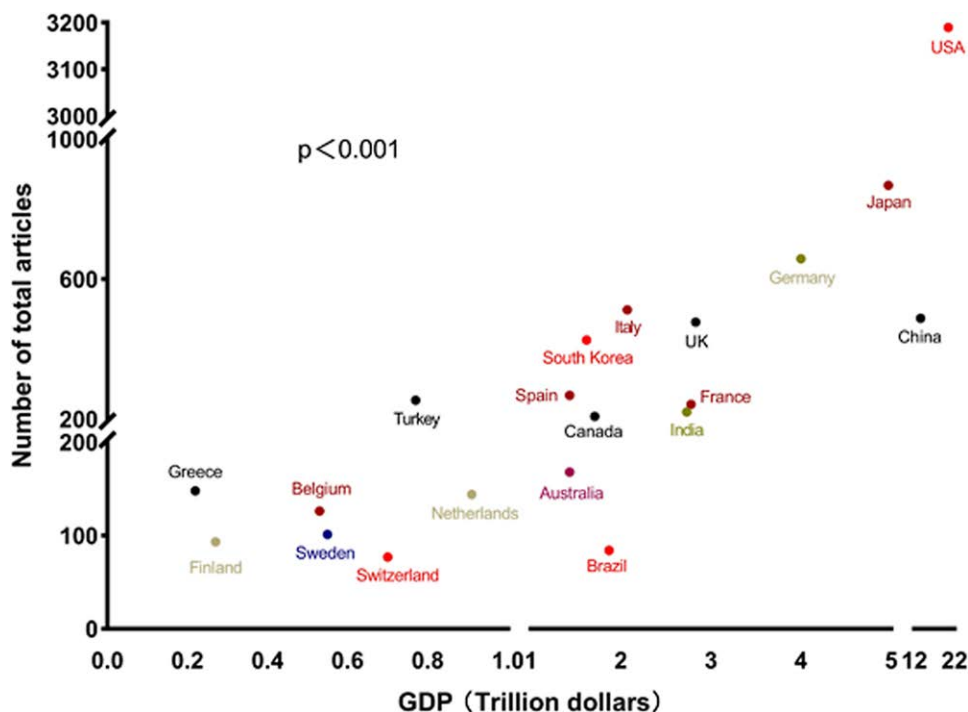


Figure 2. The correlation between total articles and GDP from 20 highest-output countries.

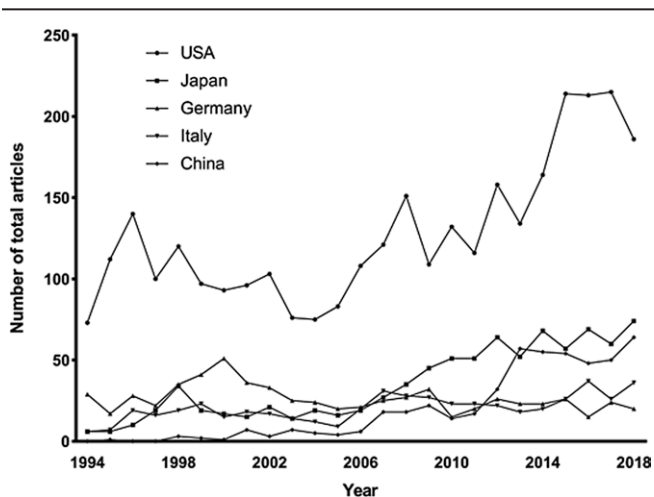


Figure 3. The trends of the total articles from 5 highest-output countries during the past 25 years.

3.6. Research highlights of ERCP

There were 1377 terms meeting the threshold of 30 (terms used more than 30 times in titles and abstracts of all publications) and 826 most relevant terms were extracted to generate the co-occurrence map (Fig. 6). The terms in the map were classified into 6 clusters: “pancreatobiliary malignancy,” “biliary diseases,” “duct stone,” “procedure,” “PEP,” and “sphincter dysfunction.” For “pancreatobiliary malignancy,” the keywords were diagnosis, sensitivity, and tumor. For “biliary disease,” the keywords were bile leak, mental stent, and benign biliary stricture. For “duct stone,” the keywords were LC (laparoscopic cholecystectomy), duct stone, and cholangiography. For “procedure,” the keywords were cannulation, risk factor, and success rate. For “PEP,” the keywords were PEP, incidence, and severity. For “sphincter dysfunction,” the keywords were sphincter, sedation, and score.

4. Discussion

The 20 countries with highest output are mainly economically developed countries located in the northern hemisphere. Countries with higher GDP tend to publish more. These countries generally have advanced ERCP training centers that provide enough physicians trained in ERCP to meet the needs of endoscopic treatment of patients with pancreaticobiliary disease. Therefore, the number of ERCP in these countries is sufficient to support relevant research, which continue to improve ERCP procedures, creating a virtuous circle.

The top 4 countries with most articles and articles per capita showed significant increases in the field of ERCP over the last 25 years. Despite a history of over 50 years, ERCP has been receiving increasing attention due to its prominent therapeutic role in clinical practice. With the development of new applications of ERCP, such as cholangioscopy and pancreatoscopy-guided lithotripsy, biodegradable biliary stents, ERCP-targeted bile duct application of radiofrequency ablation and photodynamic therapy for unresectable hilar cholangiocarcinoma, etc.^[16–19] it is reasonable to infer that there is a promising prospect for ERCP. As the only developing country, despite its great progress, China remained at the bottom of the 5 countries in outputs per capita. Given that ERCP practitioners (ERCPists) were the mainstay of ERCP research, the output per capita was mainly influenced by the number of ERCPists. In 2012, the proportion of ERCPist in the population of China was 2.47 per million, far lower than 20 per million in developed countries, and 60.1% of Chinese ERCPists had been practicing ERCP for <math>< 5</math> years.^[2,20] Compared with developed countries, the quantity and quality of ERCPists still need to be improved in China. The total output, output per capita, and average IF in Germany were on downward trends. Unlike other developed countries that had established a complete tiered medical services system, there were many senior endoscopists performing basic endoscopy in Germany. Meanwhile, Germany was beset by the problem that a growing number of German physicians emigrated abroad.^[21,22] Besides, the aging of population is an issue that cannot be ignored. The proportion of the population aged

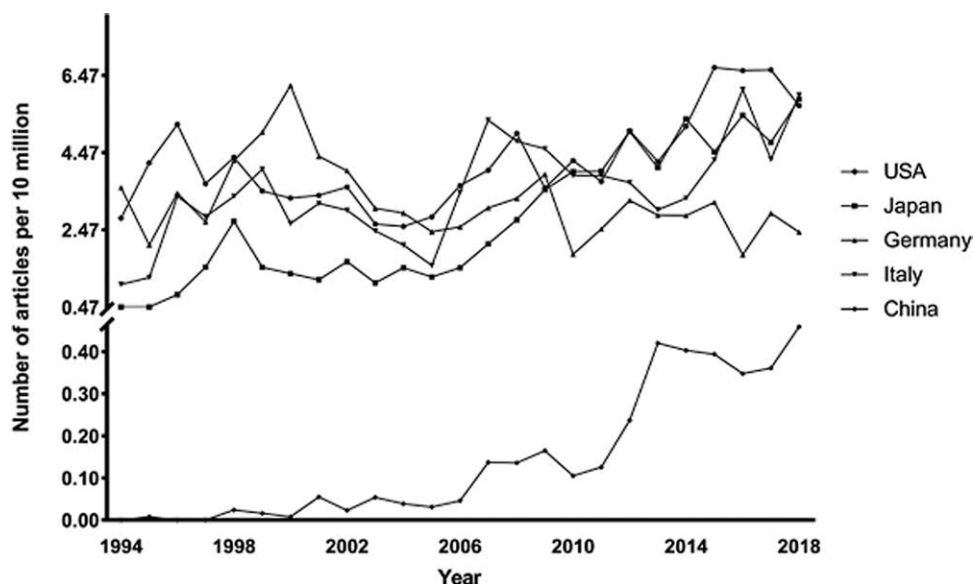


Figure 4. The trends of numbers of articles per 10 million from 5 highest-output countries during the past 25 years.

Table 2
Number of articles published in 10 highest impact factors journals.

Rank	Journal	2018 IF	Country					Total
			USA	Japan	Germany	Italy	China	
1	NEJM	70.670	12	0	2	2	0	16
2	Lancet	59.102	3	0	3	0	1	7
3	Nature	43.070	0	0	0	0	0	0
4	Lancet Oncology	35.386	0	0	0	0	0	0
5	NRDP	32.274	0	0	0	0	0	0
6	JCO	28.245	1	0	0	0	0	1
7	Nature Genetics	25.455	0	0	0	0	0	0
8	Physiological Reviews	24.25	0	0	0	0	0	0
9	Cancer Cell	23.916	0	0	0	0	0	0
10	JAMA Oncology	22.416	1	0	0	1	0	1
	Total		17	0	5	2	1	25

IF = impact factors; NEJM = New England Journal of Medicine; NRDP = Nature Reviews Disease Primers; JCO = Journal of Clinical Oncology.

Table 3
The accumulated IF, average IF, total citation, and average citation of 5 top-ranking countries.

Country	Total Articles	Accumulated IF	Average IF	Total Citation	Average Citation
USA	3190	20588.365	6.454	60,761	19.05
Japan	868	3405.699	3.924	12,816	14.76
Germany	658	2955.590	4.492	12,525	19.03
Italy	512	2439.112	4.764	10,361	20.23
China	488	1524.870	3.125	4504	9.23

15–64 has been declining over the 30 years in Germany, which indicates a declining reserve of physicians.^[14] The above factors may affect the number of ERCP procedures or ERCPists, ultimately leading to a decrease in ERCP-related studies.

As for the most popular journals, all 5 countries had their own journals on the list. *GIE* and *Endoscopy* appeared on the list of all top 5 producing countries. *GIE* is the official publication of the American Society for Gastrointestinal Endoscopy and *Endoscopy* is the official publication of the European Society of Gastrointestinal Endoscopy. These two journals are

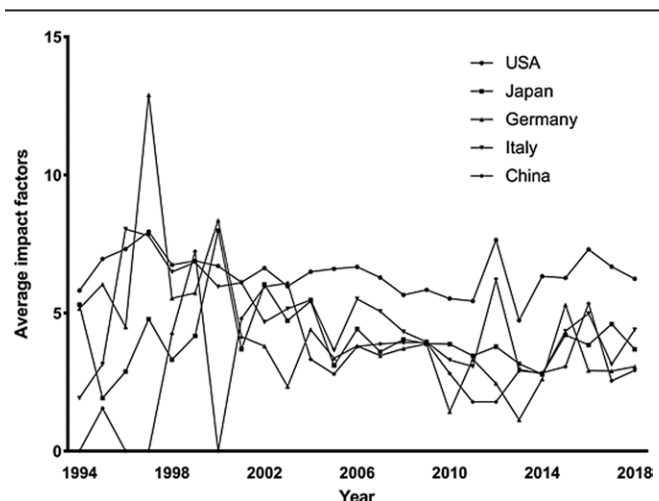


Figure 5. The trends of average impact factors of 5 highest-output countries during the past 25 years.

Table 4
The most popular journals of 5 highest-output countries.

USA		Japan		Germany		Italy		China	
Journal	Number	Journal	Number	Journal	Number	Journal	Number	Journal	Number
<i>GIE</i>	1075	<i>GIE</i>	136	<i>Endoscopy</i>	80	<i>DLD</i>	69	<i>GIE</i>	51
<i>AJG</i>	457	<i>DE</i>	95	<i>ZFG</i>	67	<i>GIE</i>	68	<i>WJG</i>	42
<i>Endoscopy</i>	154	<i>JGH</i>	75	<i>GIE</i>	66	<i>Endoscopy</i>	56	<i>JGH</i>	39
<i>DDS</i>	118	<i>Endoscopy</i>	47	<i>Gastroenterology</i>	32	<i>SEOIT</i>	21	<i>Endoscopy</i>	18
<i>Gastroenterology</i>	84	<i>JOG</i>	47	<i>EH</i>	25	<i>AJG</i>	19	<i>HPDI</i>	17
<i>SEOIT</i>	75	<i>WJG</i>	42	<i>DMW</i>	24	<i>Gastroenterology</i>	18	<i>Medicine</i>	16
<i>CGH</i>	68	<i>HG</i>	41	<i>ZFC</i>	24	<i>WJG</i>	14	<i>DE</i>	15
<i>JCG</i>	66	<i>JHBPS</i>	37	<i>Chirurg</i>	18	<i>AJG</i>	14	<i>HG</i>	14
<i>Pancreas</i>	66	<i>IM</i>	33	<i>SJG</i>	15	<i>SEUIT</i>	10	<i>AJG</i>	13
<i>AS</i>	44	<i>Pancreas</i>	29	<i>SEOIT</i>	13	<i>HG</i>	9	<i>SEOIT</i>	13

GIE, Gastrointestinal Endoscopy, IF = 7.229; *Endoscopy*, IF = 6.381; *DLD*, Digestive and Liver Disease, IF = 3.037; *AJG*, American Journal of Gastroenterology, IF = 10.241; *DE*, Digestive Endoscopy, IF = 3.640; *ZFG*, Zeitschrift Fur Gastroenterologie, IF = 1.236; *WJG*, World Journal Of Gastroenterology, IF = 3.411; *JGH*, Journal of Gastroenterology and Hepatology, IF = 3.632; *DDS*, Digestive Diseases And Sciences, IF = 2.937; *Gastroenterology*, IF = 19.233; *SEOIT*, Surgical Endoscopy and Other Interventional Techniques, IF = 3.209; *JOG*, Journal of Gastroenterology, IF = 5.130; *EH*, Endoskopie Heute, IF None; *HPDI*, Hepatobiliary Pancreatic Diseases International, IF None; *DMW*, Deutsche Medizinische Wochenschrift, IF = 0.635; *Medicine*, IF = 1.870; *CGH*, Clinical Gastroenterology and Hepatology, IF = 7.958; *HG*, Hepato Gastroenterology, IF None; *ZFC*, Zentralblatt Fur Chirurgie, IF = 0.623; *JCG*, Journal of Clinical Gastroenterology, IF = 2.724; *JHBPS*, Journal of Hepato Biliary Pancreatic Sciences, IF None; *Chirurg*, IF = 0.669; *AJG*, Annali Italiani Di Chirurgia, IF = 0.793; *Pancreas*, IF = 2.675; *IM*, Internal Medicine, IF = 0.956; *SJG*, Scandinavian Journal of Gastroenterology, IF = 2.152; *SEUIT*, Surgical Endoscopy Ultrasound and Interventional Techniques, IF None; *AS*, American Surgeon, IF = 0.610.

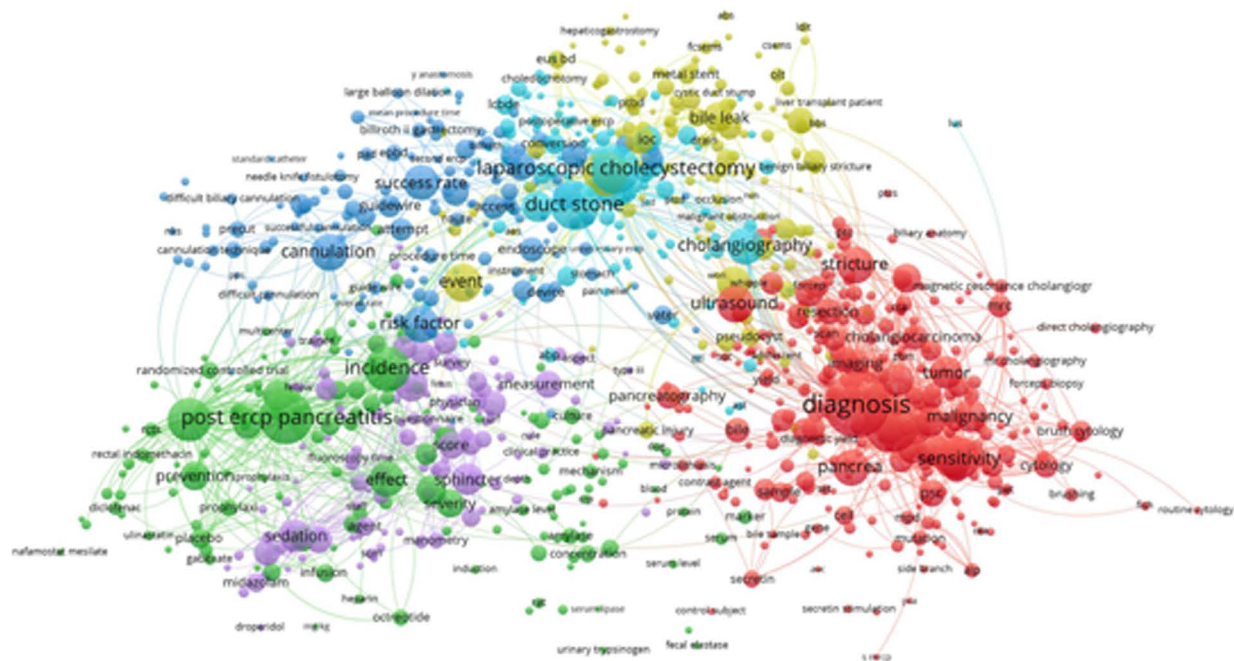


Figure 6. The co-occurrence network map of researches on the field of ERCP. Each circle represents 1 term and terms with larger circles tend to be used more frequently. Terms shown with the same color mean the frequency of co-occurrence is higher and are listed together. The closer 2 terms in the map, the stronger their relation.

authoritative journals in the field of digestive diseases and are the major submission journals of global ERCP researchers. Based on the results of the co-occurrence analysis, research focus and popular topics in the ERCP field were discovered. Over the past 25 years, the term “diagnosis” appeared most frequently in the cluster of “pancreatobiliary malignancy.” Although the role of ERCP in the diagnosis of pancreatobiliary malignancy has been partially replaced by EUS-guided fine-needle aspiration (EUS-FNA), the ERCP-based Spyglass system has been proven effective in the diagnosis of cholangiocarcinoma in patients with negative results by EUS-FNA, especially for tumor such as intraductal papillary mucinous

neoplasm.^[23,24] In addition to its diagnostic role, new ERCP-based therapies, such as endobiliary brachytherapy, photodynamic therapy, and radiofrequency ablation, are also receiving more attention.^[25,26] In cholelithiasis, LC with intraoperative ERCP has been proved as a safe and feasible strategy for the management of cholelithiasis and choledocholithiasis, with less cost, shorter length of hospital stays, and shorter anesthesia time.^[27–29] As for PEP, research is mainly focused on prophylaxis medications, such as indomethacin or diclofenac.^[30] For “sphincter dysfunction,” the necessity of ERCP for patients with sphincter of Oddi dysfunction (SOD) remains a controversial issue. A randomized clinical trial indicated that ERCP

and sphincterotomy were not required to improve postcholecystectomy pain in patients with type SOD, as there was no difference in the improvement of pain the between sphincterotomy group and sham group.^[31]

This study has limitations. First, publications from China were searched using “People’s Republic of China” under the “Countries/Regions” category of WOS, therefore, publications from Taiwan weren’t included. Second, some high-quality articles published in journals that were not included in the SCIE database were not retrieved. Third, some articles were completed by authors from different countries. There may be duplication of publications among countries.

In conclusion, the number of ERCP studies in the top producing countries, except for Germany, will continue to increase. The quality of articles and outputs per capita of developed countries were higher than those of developing countries. The ERCP for SOD and the combination of ERCP and LC were high-frequency keywords in ERCP field, which may reflect the current research focus.

Author contributions

Huai-Yu Yang, Dan Wang and Xi Lin participated in the acquisition, analysis, and interpretation of data, as well as manuscript drafting; Chao Han, Yan-Wei Lv, Ren-Qian Huang, Jie Zhang and Zhao-Shen Li participated in data acquisition and manuscript drafting; Zhuan Liao and Liang-Hao Hu contributed to the conception, design, data interpretation and manuscript.

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