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 was 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 the highest average IF (6.454). The USA had the highest output per capita (97.5/10 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 all been easier to diagnose.[5] In the early stage of clinical application,
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). Fortunately, a series of breakthroughs have made ERCP the primary endoscopic approach for treating pancreatic and biliary diseases. Currently, there are more than 650,000 ERCP procedures per year in the USA alone. 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 1136. The total ERCP volume increased from 63,787 to 195,643, of which > 95% were therapeutic.

Despite significant growth globally, there are still some ERC-related issues remain unresolved. In clinical practice, post-ERCP pancreatitis (PEP) and ERCP-related infections are difficult complications of ERCP. 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. 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. All member states of the United Nations were included. 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 were calculated. For reviews, the USA, China, Germany, Japan, and Italy ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. For reviews, the USA, China, Germany, Japan, and Italy ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The USA ranked 1st with 3190 articles, 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 < 0.001). The USA ranked 1st with 3190 articles, followed by China, Germany, Japan, and Italy.

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 < 0.001). The USA ranked 1st with 3190 articles, followed by China, Germany, Japan, and Italy.

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 top 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 < 0.001), but a downward trend for Germany (P = 0.036, 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.
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).
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 <5 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...
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

### Table 2

**Number of articles published in 10 highest impact factors journals.**

| Rank | Journal              | 2018 IF | USA | Japan | Germany | Italy | China | Total |
|------|----------------------|---------|-----|-------|---------|------|-------|-------|
| 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| 24.26   | 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       | 0    | 0     | 1     |

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            |

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

Figure 5. The trends of average impact factors of 5 highest-output countries during the past 25 years.
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. In addition to its diagnostic role, new ERCP-based therapies, such as endobiliary brachytherapy, photodynamic therapy, and radiofrequency ablation, are also receiving more attention. 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. As for PEP, research is mainly focused on prophylaxis medications, such as indomethacin or diclofenac. 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 pain were not required to improve postcholecystectomy pain in patients with type SOD, as there was no difference in the improvement of pain between the sphincterotomy group and sham group.\textsuperscript{[9]}

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 quantity 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; Zhan Liao and Liang-Hao Hu contributed to the conception, design, data interpretation and manuscript.

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