Global trends of researches on radioactive enteritis: A bibliometric and visualization study

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Abstract

Background: Radiation enteritis (RE) caused by radiation therapy, can seriously affect human health. Recently, studies on RE have been growing rapidly, but there are no bibliometric studies on RE. This study aims to explore the development trends and research hotspots of RE.

Methods: Academic papers on the Web of Science were retrieved on the topic of “radioactive enteritis” from the establishment of the database to December 2020. Countries, institutions, and subjects selected in this field were visualized using Citespace, HistCite, and Vosviewer. The annual trends in publications, distribution, co-authorship status, and research hotspots were analyzed.

Results: The authors ranked first in terms of publication amount were Delaney, Francois, Milliat, and Vozenin-Brotons. The United States had the highest number of posts, followed by China, France, the United Kingdom, and Spain.

Conclusion: Future research in the field of RE will focus on double-blind clinical trials of RE, and the related mechanisms, such as oxidative stress and apoptosis.

Abbreviations: RE = radiation enteritis, WOS = Web of Science.

Keywords: bibliometric analysis, radiation enteritis, research trends, visualization

1. Introduction

Radiation enteritis (RE) is an intestinal injury caused by radiotherapy for pelvic and abdominal malignant tumors. RE can be divided into acute and chronic RE according to the time of onset, and radiation small enteritis, colitis, and proctitis according to the site of the onset. Most of the clinical manifestations are abdominal pain, diarrhea, bloody stool, and even septicemia, multiple organ dysfunction syndrome, endangering the life of patients. The study found that >75% of patients with pelvic radiotherapy will develop acute proctitis and 5% to 20% of patients will develop chronic proctitis. At present, the main treatment of acute RE is symptomatic treatment, and chronic patients often need surgical treatment.

Citespace, HistCite, and Vosviewer are gradually developed citation visualization analysis software under the background of data visualization. Through the analysis and integration of literature information, the 3 software use the “scientific knowledge graph” to present the basic knowledge, research progress, and research frontiers in a certain field. In this study, Citespace, HistCite, and Vosviewer were used to reveal the research progress and frontier of RE.

2. Materials and Methods

2.1. Data sources

We used the Web of Science (WOS) with radiation enteritis as the keywords to search articles from the establishment of the database to December 2020, without any restrictions on literature types and languages, and finally, 716 articles were included.
2.2. Data processing

All articles were imported into Citespace and Vosviewer for analysis in plain text and tab-separated formats, in which Citespace was used to analyze cited authors and cited literature of articles, generated journal superposition graphs and burst detection of cited literature, and Vosviewer was used to analyze countries, cited institutions, and subject words of articles.

2.3. Data overview

There are 716 articles about RE in English, of which the first study was published in 1950, while less than 10 articles were published every year before 1985. Since 1991, the number of articles had remained above double digits, and the number of articles has shown a steady growth trend from 1985 to 2020. In terms of literature language, a total of 716 articles published in 7 languages were retrieved by the WOS. Of the 716 articles, 673 (93.994%) were published in English, 21 (2.933%) in French, 13 (1.816%) in Spanish, 6 (0.838%) in German, and 1 each in Chinese, Czech, and Serbian (0.14%).

3. Results

3.1. The countries and institutions

A total of 45 countries have contributed to RE research. With the threshold set to 2, Vosviewer was used to create a graph of country publishing articles with a frequency >2. Figure 1 shows 24 nodes, 86 connections, 8 clusters, and active cooperation among the countries represented by clusters corresponding to different colors. The top 6 countries are the United States (219, 30.587%), China (90, 12.57%), France (73, 10.196%), the United Kingdom (51, 7.123%), Spain (39, 5.447%), Italy (32, 4.469%), and Turkey (32, 4.469%). Other countries or regions published 232 articles, accounting for about 32.4% of the total literature.

In the network diagram of the cited institutions, there are 161 nodes and 989 connections (Fig. 2). The 161 institutions in the diagram form a total of 12 clusters, of which cluster 1 has the most institutions, with 26 institutions (14.69%), followed by cluster 2 (20, 11.30%), cluster 3 (19, 10.73%), cluster 4 (16, 9.04%), and other 12 clusters. Among the cited institutions, active cooperation has been carried out, especially among those in the same cluster.

3.2. The author and cited author

For international research, there are 3319 authors retrieved from 716 articles. Table 1 shows the top 7 authors (4 authors tied for 7th place, a total of 10) and the cited authors. The top 7 authors contributed 92 (12.85%) articles. Delaney and Francois had the largest number of articles, with the same number of 11 (1.536%), followed by Milliat and Vozenin-Brotons, with the same number of 10 (1.397%).

Co-cited author means that the authors’ articles are cited by different authors at the same time. The ranking of authors and cited authors, and the map of cited authors are shown in Table 1 and Figure 3 respectively. Among the top 10 cited authors,
Galland ranked first with 87 (2.53%) times, followed by Yeoh with 55 (1.60%), Kinsella with 49 (1.43%), Decosse with 46 (1.43%), and Andreyev with 43 (1.25%), while the rest of the authors were cited <31 times.

### 3.3. Journals and cited journals

A total of 716 articles were published in 312 journals in the international research. Tables 2 and 3 list the top 7 journals and cited journals in the field of RE. The top 7 journals have published 129 articles (18.02%). *International Journal of Radiation Oncology Biology Physics* (39, 5.447%) ranks first, followed by *Diseases of the Colon Rectum* (21, 2.933%), *Gastroenterology* (17, 2.374%), *Radiotherapy and Oncology* (15, 2.095%), and *Digestive Diseases and Sciences* (14, 1.955%). Among the top 7 journals, 6 are from the United States and 1 from the Netherlands, and the impact factors of 6 journals are <6.000.

Co-cited journals refer to journals that are cited by other scholars. Among the cited journals, *International Journal of Radiation Oncology Biology Physics* (334, 4.94%), *Gastroenterology* (200, 2.96%), *Diseases of the Colon Rectum* (182, 2.69%), *Cancer* (182, 2.69%), and *Lancet* (175, 2.59%) are the top 5. The top 7 journals are cited more than or equal to 170 times; 71.43% of the top 7 journals are from the United States, and 42.86% of the journals have an impact factor higher than 6.000.

![Network diagram of cited institutions.](image)

**Figure 2.** Network diagram of cited institutions.

**Table 1**

| Rank | Author     | Article (%) | Cited author | Cited time (%) |
|------|------------|-------------|--------------|----------------|
| 1    | Delaney    | 11 (1.536%) | Galland      | 87 (2.53%)     |
| 2    | Francois   | 11 (1.536%) | Yeoh         | 55 (1.60%)     |
| 3    | Milliat    | 10 (1.397%) | Kinsella     | 49 (1.43%)     |
| 4    | Vozenin-Brotons | 10 (1.536%) | Decosse      | 46 (1.43%)     |
| 5    | Bourhis    | 9 (1.257%)  | Andreyev     | 43 (1.25%)     |
| 6    | Li         | 9 (1.257%)  | Hauer-Jensen | 39 (1.14%)     |
| 7    | Andreyev   | 8 (1.117%)  | Theis        | 34 (0.99%)     |
| 7    | Erbil      | 8 (1.117%)  | Andreyev     | 34 (0.99%)     |
| 7    | Pironi     | 8 (1.117%)  | Waddell      | 31 (0.90%)     |
| 7    | Wang       | 8 (1.117%)  | Berthrong    | 31 (0.90%)     |
and clinical. The knowledge fields cited in the journals (right) mainly focus on environment, toxicology, nutrition, molecular biology, genetics, health, nursing, medicine, dermatology, surgery and sports, rehabilitation, and sports. Since the cited journals provided the knowledge base of the citing journals, the trajectory of these changes shows that the research hotspots of the journals has shifted from the fields of environment, toxicology, nutrition, genetics, nursing, sports, rehabilitation and sports to molecular biology, immunobiology, dermatology, and surgery.
3.4. Cited literature

For international research, Table 4 lists the top 10 citations related to the study of RE. The top 10 references are cited more than 202 times on average, among which 4 cited literature were cited more than 200 times. A literature with a cited burst is defined as being frequently referenced over a period of time. When analyzing references through Citespace, we set the threshold to the top 50, took every year as a time slice, selected cutting mode as pathfinder + pruning sliced networks + pruning the merged network, and finally got Figure 5, and 21 citations with strong bursts were detected (Fig. 6). In Figure 6, the blue line represents the time interval, the red line represents the time period of the outbreak. The emergence of the citation first appeared in 1991, while the literature with the highest emergence intensity began in 2011 and ended in 2018, and the latest emergence references appeared in 2014.

| Title                                                                 | Author          | Journal                      | Cited time |
|----------------------------------------------------------------------|-----------------|------------------------------|------------|
| Leukocyte-endothelial cell interactions: Molecular mechanisms and implications in gastrointestinal disease | Panes et al     | Gastroenterology             | 291        |
| Intraoperative radiotherapy in retroperitoneal sarcomas—final results of a prospective, randomized, clinical-trial | Sindela et al   | Archives of Surgery          | 253        |
| ESPEN guidelines on chronic intestinal failure in adults             | Pironi et al    | Clinical Nutrition           | 249        |
| Phase 2 multi-institutional trial evaluating gemcitabine and stereotactic body radiotherapy for patients with locally advanced unresectable pancreatic adenocarcinoma | Herman et al    | Cancer                       | 192        |
| Gut microbiota and inflammation                                      | Hakansson et al | Nutritions                   | 182        |
| Healing and fibrosis in intestinal disease                           | Rieder et al    | Gut                          | 181        |
| The dose-volume relationship of acute small bowel toxicity from concurrent 5-FU-based chemotherapy and radiation therapy for rectal cancer | Baglan et al    | International Journal of Radiation Oncology Biology Physics | 175 |
| Home parenteral nutrition in adults: a European multicentre survey in 1997 | Van Gossum et al | Clinical Nutrition           | 174        |
| 4 years of north-American registry home parenteral-nutrition outcome data and their implications for patient-management | Howard et al    | Journal of Parenteral and Enteral Nutrition | 169 |
| Survival of home parenteral nutrition-treated patients: 20 years of experience at the Mayo Clinic | Scolapio et al  | Mayo Clinic Proceedings      | 157        |

3.5. Keywords and clustering

A total of 13,350 keywords were extracted from 716 articles from international research. There were 336 keywords with a frequency of more than 10 times, the first 202 were selected to generate a density visualization map with Vosviewer (Fig. 7).

As shown in Table 5, effect is the most important keyword, with a total of 193 times, followed by complication (151), irradiation (151), surgery (124), injury (122), case (118), and level (103). Among the top 20 keywords, some are related to the etiology and pathological mechanisms of RE, such as irradiation, injury, tissue, cancer, and chemotherapy. Others are mostly related to treatment, such as surgery and resection. Some are related to experimental modeling, such as Eat and Model.

Co-occurrence keywords was clustered and analyzed. Vosviewer was used to create a visual map of keywords (Fig. 8). The software extracted the keywords from the titles and abstracts of 716 articles, calculated the cumulative frequency of the keywords, and set the threshold to 40.00%, because the keywords with a high frequency can accurately display the topic of a field. After calculation, the keyword network diagram was generated. There are 202 nodes and 10,957 connections in the network diagram, and these high-frequency keywords form 2 clusters (Fig. 8). Category 1 has the largest number of keywords, with a total of 110 keywords, which are mainly related to the etiology and complications of RE, such as carcinoma, cervical...
cancer, chemoradiotherapy, bowel obstruction, fistula, cystitis, etc. Category 2 has 92 keywords, which are mainly related to the influence, clinical trials and animal experiments of RE, such as injury, irradiated mice, animal model, control group, double blind, and so on.

4. Discussion

We used the core collection in the WOS as the data source, including 716 articles. A total of 45 countries have participated in the publication of 716 articles in this field, of which the United States ranks first, followed by China, France, Britain, and Spain. Although the number of articles published in China is second only to the United States, the number of articles published in the United States is about 2.5 times that of China, reflecting the large gap in the frequency and depth of research between China and the United States. A total of 906 international institutions have participated in the publication of the articles in this field. The top 5 institutions are the Gustav Luci Institute in France, the Mayo Medical Center and the Sloan Kettering Cancer Institute in the United States, Nanjing University in China, and Royal Adelaide Hospital in Australia. Nanjing University in China has a certain influence in the international research of RE, but it lacks cooperation with international institutions.

A total of 129 articles were published in the top 7 international journals in the field of RE, accounting for 18.02% of all literature. Among the top 7 journals, 6 were from the United States and 1 was from the Netherlands. Among the 7 journals, the highest impact factor was 6.36, the lowest was 2.751, and the average was 4.7896. Among all cited journals, the top 7
Journals have the highest impact factor of 60.391 and the lowest of 3.991, with an average of 15.7. Among the top 7 cited journals, 5 journals (71.43%) are from the United States, followed by the Netherlands and the United Kingdom, each with 1 journal.

A total of 3319 authors participated in the publication of international literature, and the top 7 authors contributed 92 (12.85%) articles. In terms of the number of articles, the key authors are Delaney, Francois, Milliat, and Vozenin-Brotons. In terms of cited frequency, the key authors are Galland, Yeo, Kinsella, Decosse, and Andreiev.

Among the cited international literature, the most cited literature is the review published in 1998 by Panes et al. This review discusses that related adhesion molecules from different families participated in the coordinated recruitment of leukocytes into inflammatory tissues, and the pathophysiological change was observed in experimental models of gastrointestinal diseases, including ischemia or reperfusion injury, RE, inflammatory bowel disease, and inflammatory response to substances released by Helicobacter pylori and Clostridium difficile.[18] The second most cited literature is a prospective randomized clinical trial of intraoperative radiotherapy for retroperitoneal sarcoma published in Archives of Surgery by Sindela et al.[19] The third is the adult chronic intestinal failure guide from European Society of Parenteral and Enteral Nutrition (ESPEN) published by Pironi et al in Clinical Nutrition.[20]

In terms of subject words, 13,350 subject words have been used in the field of RE, of which only 68 have a frequency greater than or equal to 30, indicating that the utilization rate of most subject words is not high. The main high-frequency subject words are radiation (416, 24.16%), enteritis (266, 12.54%), intestinal (105, 6.10%), induced (104, 6.03%), patients (91, 5.28%), cancer (82, 4.76%), and radiotherapy (80, 4.65%). The high-frequency subject words formed 2 clusters, and the first category had the largest number of subject words, with a total of 110 subject words, which were mainly related to the etiology and complications of RE. The second category had 92 subject words, which were mainly related to the influence of RE, clinical trials, and animal experiments. According to the burst detection of keywords (Fig. 9), it is predicted that clinical double-blind trial of RE, the related mechanisms such as oxidative stress and

![Figure 7. Visualization map of density.](image)

**Table 5**

| Rank | Keywords | Frequency | Rank | Keywords | Frequency |
|------|----------|-----------|------|----------|-----------|
| 1    | Effect   | 193       | 11   | Grade    | 80        |
| 2    | Complication | 151     | 12   | Rat      | 75        |
| 3    | Irradiation | 151      | 13   | Damage   | 74        |
| 4    | Surgery  | 124       | 14   | Change   | 72        |
| 5    | Injury   | 122       | 15   | Management | 70      |
| 6    | Case     | 118       | 16   | Tissue   | 64        |
| 7    | Level    | 103       | 17   | Carcinoma| 63        |
| 8    | Chemotherapy | 87       | 18   | Model    | 63        |
| 9    | Cell     | 82        | 19   | Outcome  | 63        |
| 10   | Resection| 82        | 20   | Morbidity| 62        |
apoptosis will become the future research hotspot in the field of international RE.

5. Conclusion
Considering that the scientific metrological analysis of RE has not been found yet, this study aims to provide researchers with an overview of research in this field, in order to show its development status and research hotspots. On the basis of the summary of this paper, statistical analysis methods will be used to further compare the results and data differences of relevant literature in the future, in order to obtain more comprehensive and complete analysis results.

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