




# Current Status and Global Trend of Rebound Pain After Regional Anesthesia: A Bibliometric Analysis

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**Purpose:** Rebound pain after regional anesthesia, a common phenomenon when the analgesic effect wears off, has been recognized in the last a few years. The aim of this study is to analyze the status and tendency of this area in a macroscopic perspective.

**Methods:** Bibliometric analysis is the primary methodology of this study. Literature retrieval was conducted in Web of Science (WoS) Core Collection. WoS, Excel, VOSviewer and CiteSpace were employed to do the analyses and visualization. Parameters were analyzed, such as publications, citations, journals, and keywords, etc.

**Results:** In total, 70 articles in the past 10 years were identified eligible. Most articles (14 pieces) were published in 2021, followed by 2022 and 2023 with 13 articles. Researchers come from 134 institutions and 20 countries. Huang Jung-Taek, Hallym College, and USA are the most productive author, institution and country, respectively. The articles were mainly published on the top journals of anesthesiology, orthopedics and surgery. The topic of these articles is primarily about the clinical issues of rebound pain. Peripheral nerve block, brachial plexus block and femoral nerve block are the activist keywords in the area, while perioperative management, fracture surgery and outcome may become hotspots in the next years.

**Conclusion:** Our results show that the study of rebound pain after regional anesthesia starts relatively late and is in upward tendency, future studies can focus on the perioperative management and outcomes of fracture patients, and the definition and mechanism of rebound pain after regional anesthesia.

**Keywords:** regional anesthesia, peripheral nerve block, rebound pain, bibliometrics

## Introduction

Rebound pain is a kind of acute pain that occurs in the first a few hours after regional anesthesia effect wears off. As suggested, the primary characteristics of rebound pain include: (1) the pain score is no less than 7 points, (2) the property of pain is burning or dull, (3) it can occur either during physical activity or while resting and last around 2 hours, and (4) the time window is the first 12 to 24 h after the regional anesthesia has worn off.<sup>1</sup> Although rebound pain has no significant impacts on postoperative recovery quality or outcomes after surgery of the patients, it can add extra worries and remains to be the main factor associated with low level of patient satisfaction with analgesia.<sup>2-4</sup> The incidence of rebound pain has been reported to be an astonishing 50%.<sup>2,3</sup> Therefore, attention should be paid to the identification, prevention and treatment of rebound pain.

Previous studies have identified some risk factors of rebound pain, such as younger age, female, orthopedic surgery, particular peripheral nerve block, and uneven sense of expectation.<sup>3-7</sup> In order to prevent rebound pain, measures have been taken. Intravenous administration of dexamethasone has been reported to reduce the incidence and severity of rebound pain.<sup>8,9</sup> Lee et al<sup>10</sup> further determined that intravenous injection rather than regional injection of dexamethasone was more efficient in preventing rebound pain. Multimodal analgesia, especially patient controlled analgesia (PCA)

combined with peripheral nerve block provided better postoperative pain control.<sup>11</sup> Besides, preoperative propaganda and education of the pain management strategy to the patients may be suggested to relieve pain-related anxiety.<sup>12</sup>

Since the phenomenon of rebound pain was observed, its significance to either patients, anesthesiologists, or surgeons has been gradually recognized. Due to the high incidence of rebound pain, it is worth to study further. Unfortunately, the research status and global trend of rebound pain have not been reported, which is not convenient for the investigators to quickly concentrate on valuable research topics. Bibliometrics is an interdisciplinary science that consists of quantitative analysis of literatures by mathematical and statistical methods. Applications of bibliometrics include determining core documents, evaluating publications, examining the utilization rate of documents, and realizing the scientific management of library and information department.<sup>13,14</sup>

However, bibliometric analyses depend on the support of mathematical tools and statistical techniques. In this study, Excel, CiteSpace and VOSviewer software were applied to present visualization of the global trend on rebound pain.

## Methods

### Literature Retrieval

Web of Science (WoS) Core Collection database was selected as the retrieval source. Records in WoS Core Collection contain unabridged 29 items of bibliometric parameters, including “Author, Title, Source”, “Abstract, Keyword, Address”, “Cited References and Use” and “Funding and Other”.

The retrieval strategy was shown as follows: (TS=rebound pain OR TS=rebound hyperalgesia OR TS=hyperalgesia TS=rebounding pain) AND (TS=regional anesthesia OR TS=nerve block OR TS=local anesthesia OR TS=peripheral nerve block). “TS” means topic in WoS, which represents searching in the title, abstract, author keywords, and Keywords Plus. Article search was conducted on 18 November 2023.

### Literature Selection

“Article”, “Clinical Trial” and “Review Article” options under “Document Types” were checked. Publication years were from 2014 to 2023. No other filters were applied. Articles on the rebound pain after regional anesthesia were considered eligible. Those on withdrawal pain, neuropathic pain and opioid-induced hyperalgesia were excluded.

Two independent investigators screened the title and abstract to determine the eligibility, a third investigator moderated the discussion on disagreements.

### Data Analyses and Visualization

All of the 29 items were extracted into a text file. Science author distribution law (Lotka’s Law) was used to describe the law of the quantitative relationship between the author and the article count. Zipf’s Law was employed to present the frequency of words. Article distribution in journals was analyzed on the basis of Bradford Law. Specifically, key information such as annual number of publications, authors, citations, countries, keywords and the trends were taken into systematic analyses. Professional tools like CiteSpace software (version 6.2.R4) and VOSviewer (version 1.6.20) were utilized to do the basic analyses and visualization.

## Results

Flowchart of the present study was displayed in [Figure 1](#). A total of 2345 articles were retrieved in WoS core database. There were 2185 articles tagged “Article”, “Clinical Trial” or “Review Article”, 934 were published in the last 10 years (2014–2023). Twenty-one articles were focused on withdrawal pain, 13 on neuropathic pain, 59 on opioid-induced hyperalgesia and 771 were not related to rebound pain. Therefore, we enrolled 70 articles, namely 63 pieces of “Article” and 7 “Review Article”. Clinical trials were merged into “Article”. In addition, there were 32 (45.7%) Open Access articles. The eligible records were accessible in [Supplement 1](#).

### Publication Trend

We used the analysis function of WoS to present the publication trend. As depicted in [Figure 2](#), in the last 10 years, articles on rebound pain after regional anesthesia is in an upward trend. The year 2021 has the most publications. Though

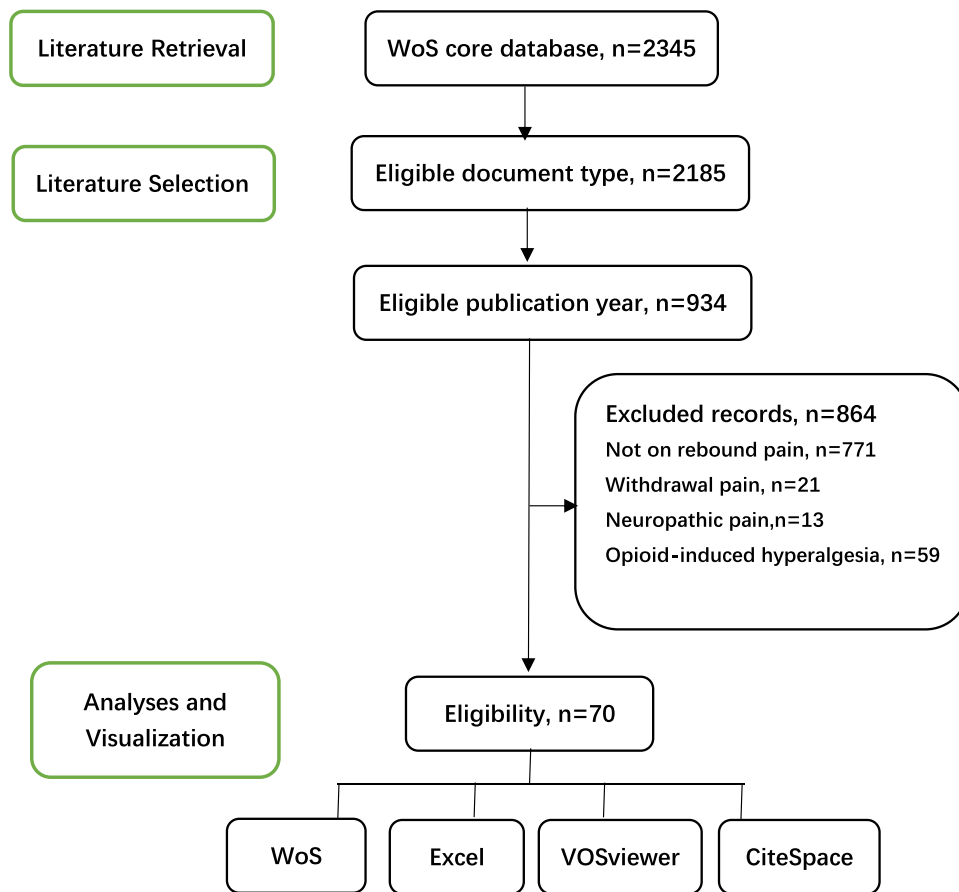


Figure 1 Flowchart of the study. WoS, Web of Science.

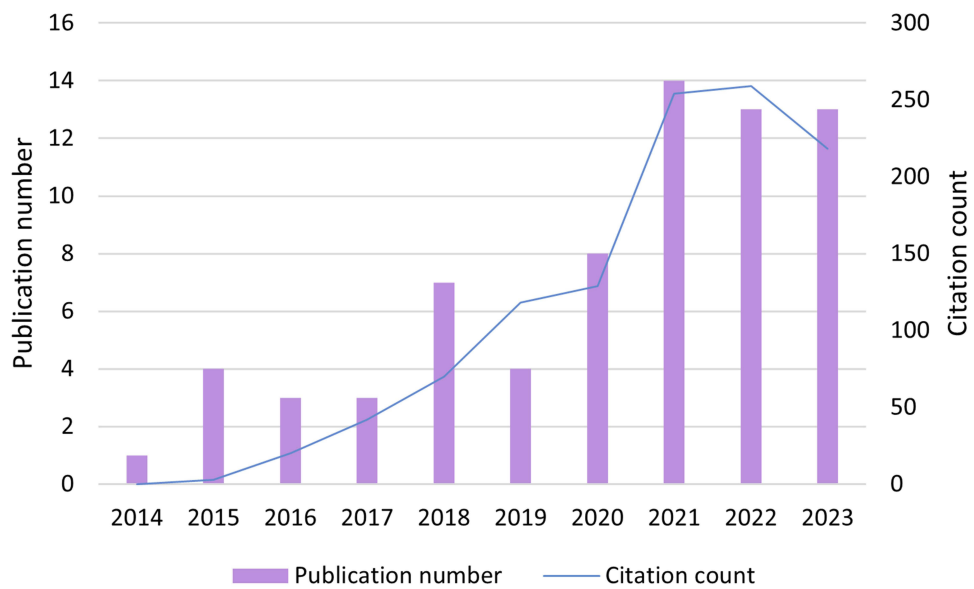


Figure 2 Changes of publication and citation count over time.

the publication number in 2023 is 1 less than 2021, it is possible to surpass. The citation tendency is similar to the publication, which means, at least in part, the attention on rebound pain is increasing.

## Analysis of the Authors

VOSviewer was applied to analyze the author contribution and interaction. From 2014 to 2023, Huang Jung-Taek, Huang Sung Mi, Kim Do-Young, Lee Jae Jun and Lee Sang-Soo are the most productive authors. The top-11 authors with publications are shown in [Figure 3A](#). However, Abdallah Faraj W. and the co-authors are the most influential authors whose articles have been cited 166 times ([Supplement 1](#)). [Figure 3B](#) and [C](#) show the link strength of the authors that is based on the times they cite each other. Lavand'homme Patricia has the most interactions with the other authors.

## Institution and Country Force

Publications and citations were analyzed by institution and country to exhibit the global status of researches on rebound pain. There are 134 institutions published related works. [Figure 4A](#) shows the top-10 institutions with publications on rebound pain. Hallym College published 5 articles, followed by Herlev Gentofte University Hospital (4 articles), University of Toronto (4 articles) and University of Ulsan (4 articles). Total citations of the institutions are also displayed in [Figure 4A](#). As for the country distribution, researchers from 20 countries and regions participated in the investigation of rebound pain. USA is the most active country on the research of rebound pain, followed by South Korea and China. The 10 countries and regions with the most publications are shown in [Figure 4B](#) and [Table 1](#). Publication distribution of the top-3 countries is shown in [Figure 4C](#). As depicted, research achievements have been produced stably in USA, South Korea and China, while the publication trend is upward in China.

## Discipline and Journals

These articles were included in 14 WoS categories ([Figure 5A](#)). Anesthesiology, orthopedics and surgery are the most related discipline. Anesthesiology is the primary subject on rebound pain and has close links with other subjects ([Figure 5B](#)). The 10 journals with highest journal impactor factor (IF) are shown in [Table 2](#). There are 20 articles in the Q1 (Source: Journal Citation Reports, JCR) journals, 27 in Q2, 12 in Q3, and 7 in Q4 ([Figure 5C](#)). Besides, there are 4 articles whose journals do not receive ranks, quartiles, or percentiles, since they received a journal IF for the first time in June 2023 ([Figure 5C](#)).<sup>15–18</sup>

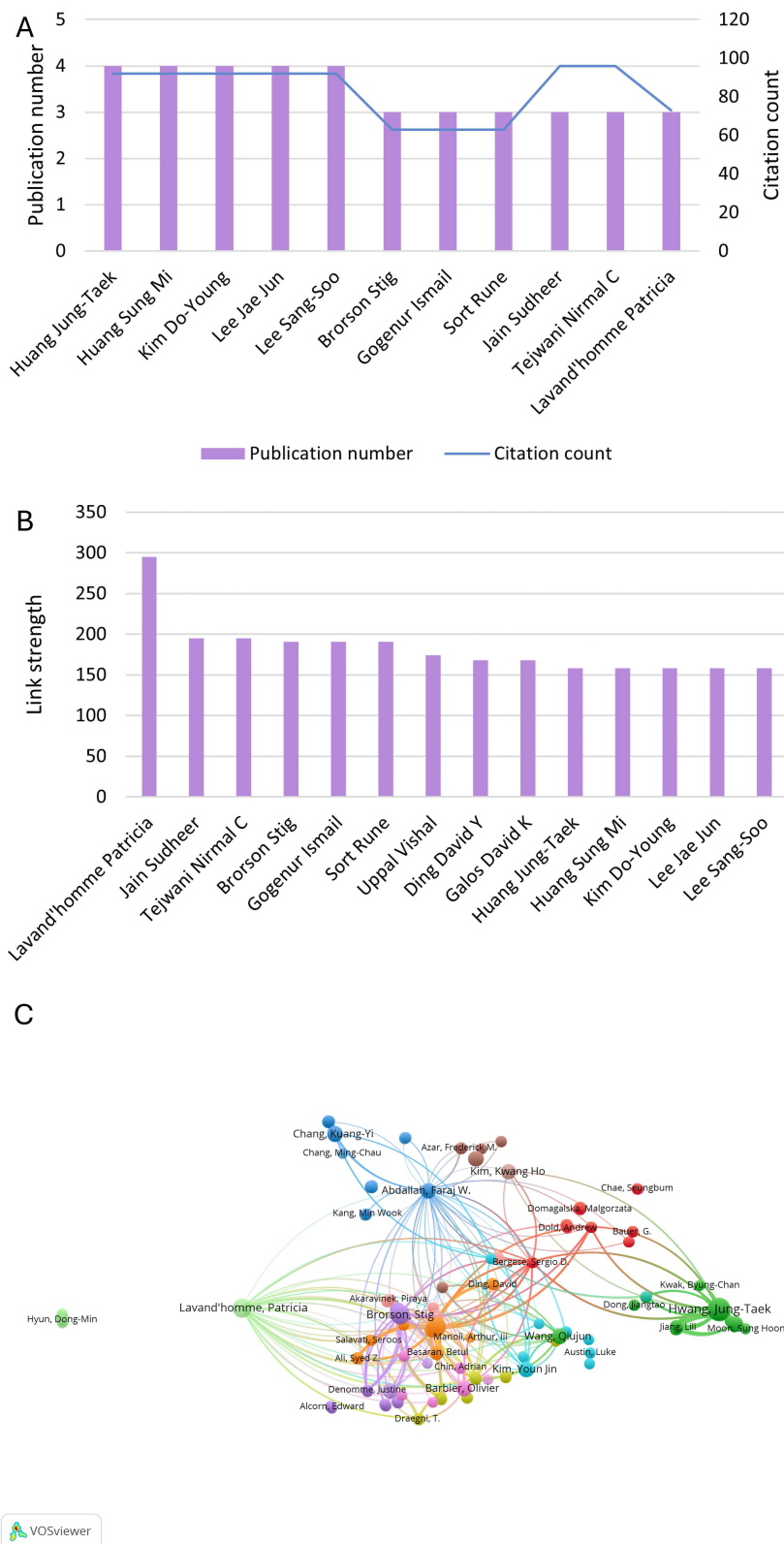
## Keywords Analyses

Top-10 frequent keywords are rebound pain (32), postoperative pain (31), analgesia (19), efficiency (15), peripheral nerve block (12), nerve block (12), interscalene block (11), brachial plexus block (11), ropivacaine (11), anesthesia (11), and management (11). [Figure 6A](#) shows the co-occurrence of the keywords added by the authors or WoS. The co-occurrence threshold was set as 10 times. Rebound pain, postoperative pain, nerve block, dexamethasone, management and duration are the latest topics ([Figure 6B](#)). However, the latest booming keywords are management, fracture surgery and outcome ([Figure 6C](#)). As shown in [Figure 6D](#), cluster #0 Peripheral nerve block is activist in the area of rebound pain research, followed by brachial plexus block and femoral nerve block.

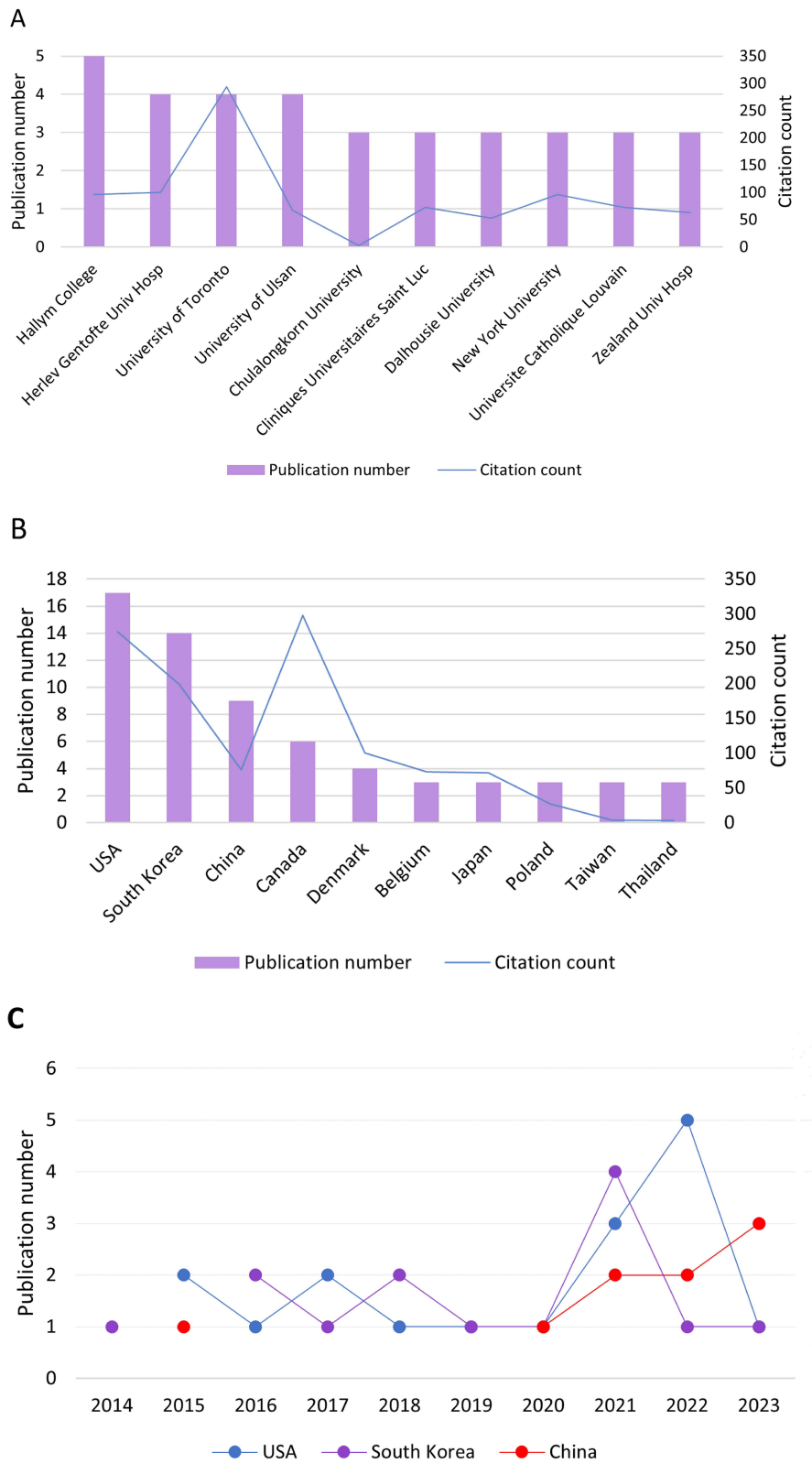
## Discussion

The present study focused on the bibliometric analyses on the research of rebound pain after regional anesthesia. Results of our study shows that the current research status of rebound pain seems to be in an initial stage, but concentration on rebound pain is increasing. Peripheral nerve block is the main mediator for investigating this problem.

The definition of rebound pain after regional anesthesia has not been united. Early description by Williams et al<sup>19</sup> is that quantifiable difference in pain scores when the block is working versus the increase in acute pain encountered during the first few hours after the effects of peri-neural single-injection or continuous infusion local anesthetics resolve, while the primary characteristics are concluded as significantly acute postoperative pain after resolution of peripheral nerve block.<sup>20</sup> Absolutely, the history of formal reports and related researches on rebound pain after regional anesthesia was believed to be short.<sup>19</sup> Therefore, the number of publications on rebound pain is small. However, rebound pain troubles



**Figure 3** Author analyses. **(A)** top-10 authors of publication number and the cited times. **(B)** link strength value of the 14 highest authors. **(C)** visualized connections of the authors.



**Figure 4** The 10 institutions (A) and countries or regions (B) with the highest number of publications. (C) the publication trend of USA, South Korea and China.

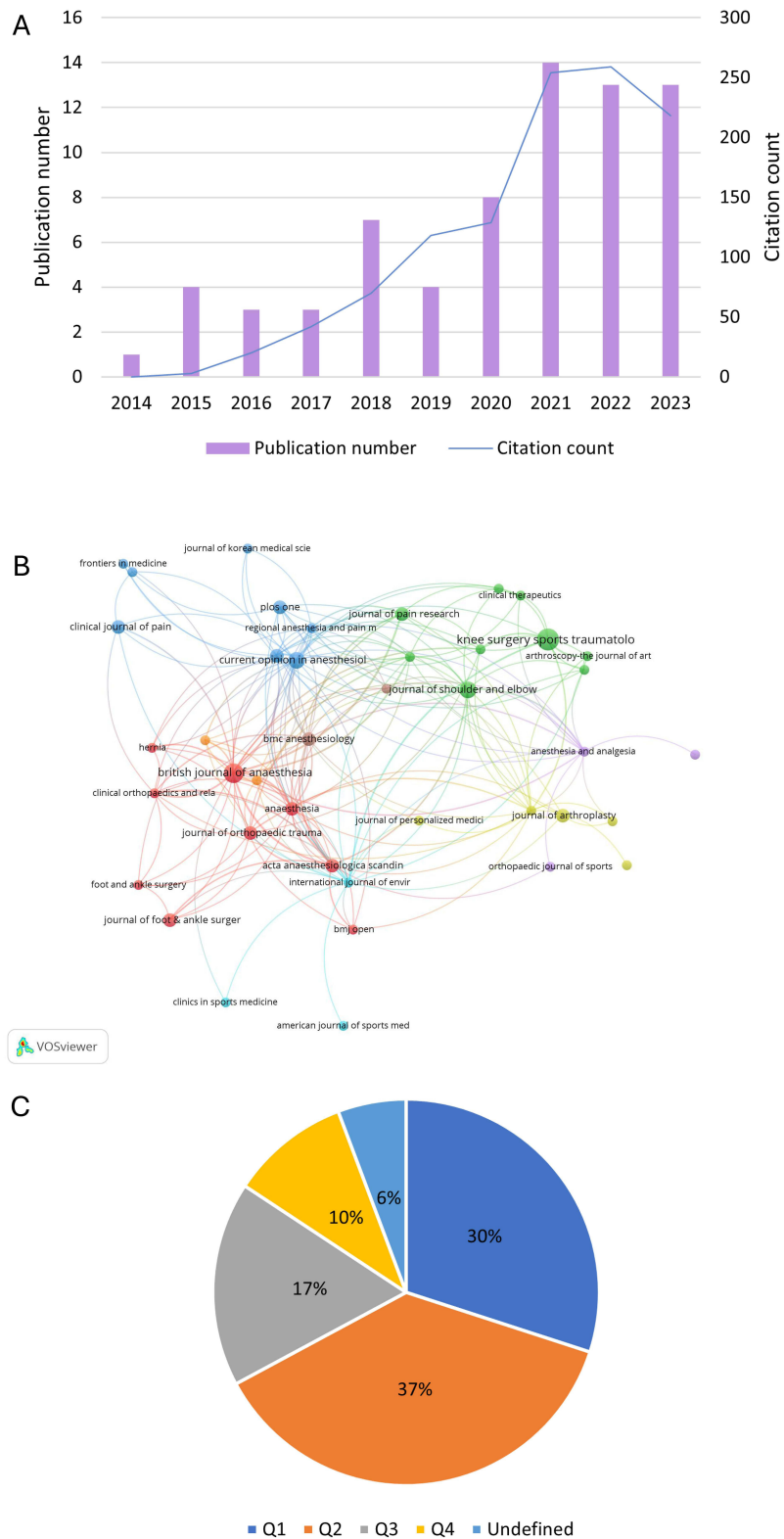
**Table 1** Annual Number of Publications of the Top-10 Countries or Regions

Variable	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
<b>USA</b>		2	1	2	1	1	1	3	5	1	17
<b>South Korea</b>	1		2	1	2	1	1	4	1	1	14
<b>China</b>		1					1	2	2	3	9
<b>Canada</b>		2					1	1	1	1	6
<b>Denmark</b>				1	1	1		1			4
<b>Belgium</b>					1				2	1	4
<b>Japan</b>					1		1			1	3
<b>Poland</b>					1					2	3
<b>Taiwan</b>									3		3
<b>Thailand</b>									1	2	3
<b>Total</b>	1	5	3	4	7	3	5	11	15	12	66

both patients and doctors.<sup>4</sup> Though rebound pain does not have significant impacts on clinical outcomes, it matters to medical workers, especially anesthesiologists. The results of our study offered some support for this view. Firstly, anesthesiology is the most active discipline in this area, followed by orthopedics and surgery. Secondly, the overall publication tendency is positive in the last 10 years and the article number bursts in the last 3 years. Thirdly, the top journals of anesthesiology have published critical works recently.<sup>2,4,21–24</sup> Moreover, the majority of these journals are located in Q1 and Q2 of the JCR evaluation system.

In the past 10 years, investigators from 134 institutions of 20 countries and regions published research achievements of rebound pain, and more countries noticed this problem. Though USA is the leading country with the most articles and scientific participants, the total cited times of Canada ranks the first. Besides, the contribution of Asia is also rising.

By analyzing the keywords, we found that peripheral nerve block, brachial plexus block and femoral nerve block in particular, played a vital role throughout the investigation of rebound pain after regional anesthesia. Peripheral nerve block is an important part of regional anesthesia and has been widely used in kinds of surgeries, especially orthopedics.<sup>2,4,24</sup> One of the risk factors of rebound pain has been reported to be blocking the regions of relatively dense nerve distribution, such as brachial plexus and popliteal space.<sup>4,6</sup> We suggest that future studies of rebound pain would better base on these findings. Another finding is that a large proportion of rebound pain prevention has been laid on anesthetic adjuvant, dexamethasone and dexmedetomidine included. One possible mechanism of rebound is that regional anesthetics can suppress inflammatory factors and cytokines which are related to activating nociceptor, and degradation of regional anesthetics induces burst of the factors.<sup>25</sup> Dexamethasone, a corticosteroid hormone, has been considered to prolong the analgesia duration of peripheral nerve block and reduce incidence of rebound pain.<sup>8,9,21</sup> Besides, absence of dexamethasone was reported to be a risk factor of rebound pain.<sup>22</sup> Our results present that dexamethasone is a hotspot in the last almost 2 years, which is in line with the previously mentioned studies. Dexmedetomidine, another adjuvant of anesthetics, has been studied to improve postoperative pain management. Recent studies indicated that dexmedetomidine strengthened analgesic effects, prolonged analgesia duration, and delayed the occurrence of rebound pain, but did not reduce the incidence of rebound pain.<sup>26,27</sup> These studies may account for the results of our study that keyword “dexmedetomidine” had a burst transitorily, but did not become a hotspot. On the contrast, postoperative pain and analgesia remained hot. It can be partly explained by the advocacy of perioperative medicine.<sup>28</sup> Last but not least, burst keywords from 2022 to 2023 include management, fracture surgery and outcome. These keywords may provide future direction for rebound pain investigation, that is paying attention to the perioperative management and outcomes of the patients, especially the fracture ones.



**Figure 5** Analyses of involved discipline and journal. **(A)** publication number of different disciplines. **(B)** visualized citation relationships of the journals. **(C)** proportion of Journal Citation Reports (JCR) quartile location of the journals.



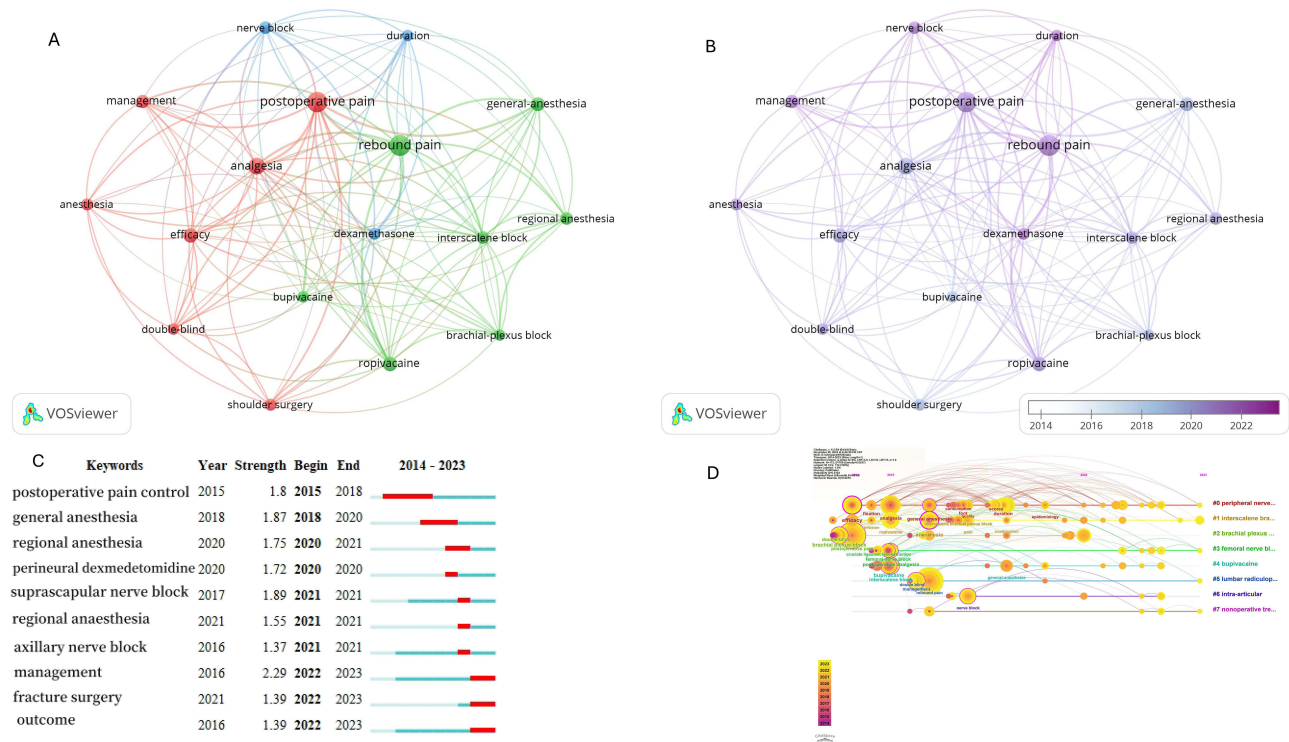
**Table 2** The 10 Journals with Highest Impact Factor (IF)

Rank	Journal	IF	Publications	JCR Quartile	Category
1	Anaesthesia	10.7	2	Q1	Anesthesiology
2	British Journal of Anaesthesia	9.8	4	Q1	Anesthesiology
3	Anesthesia and Analgesia	5.9	1	Q1	Anesthesiology
4	Regional Anesthesia and Pain Medicine	5.1	1	Q1	Anesthesiology
5	American Journal of Sports Medicine	4.8	1	Q1	Orthopedics; Sport Sciences
6	Arthroscopy-The Journal of Arthroscopic and Related Surgery	4.7	1	Q1	Orthopedics; Sport Sciences; Surgery
7	International Journal of Environmental Research and Public Health	4.614	1	Q1	Public, Environmental & Occupational Health; Environmental Sciences
8	Spine Journal	4.5	1	Q1	Orthopedics; Clinical Neurology
9	Journal of Korean Medical Science	4.5	1	Q2	Medicine, General & Internal
10	Clinical Orthopaedics and Related Research	4.3	1	Q1	Orthopedics; Surgery

**Notes:** Q1: the first quartile. Q2: the second quartile.  
**Abbreviation:** JCR, Journal Citation Reports.

### Limitations

The analyzed number of articles is relatively small. The main reason is that rebound pain after regional anesthesia has been noticed for a short time. Many studies are still in initial stage. So, we did this work to help with future studies. Owing to the human factors that affect the document information, many document problems are still difficult to quantify.



**Figure 6** Visualization of keywords analyses. (A) co-occurrence of the keywords. (B) popularity of the keywords over time. (C) 10 keywords with the highest burst index. (D) timeline of visualization of the 8 largest clusters of the keywords.

In particular, due to the high complexity and instability of the literature system, it is impossible for us to obtain sufficient and effective information to reveal the macroscopic laws of the literature. To reduce the interference of unrelated literatures to the maximum extent, we screened every retrieved record to select eligible ones. This is another reason for the small number of enrolled articles.

We only searched the articles in WoS Core Collection, which leads to missing some articles. WoS Core Collection is a scholarly literature database developed and maintained by Clarivate Analytics, which contains high-quality academic journals, conference papers and patents from around the world. Articles with high-quality rather than those with low-quality actually promoted the development of science. Besides, we did not restrict language. Therefore, some articles not in English were also included. Nevertheless, databases like PubMed and Scopus are suggested to be used for literature retrieval.

## Conclusion

The study of rebound pain after regional anesthesia starts relatively late and is in upward tendency. Previous studies mainly focused on the macroscopical vision, such as phenomenon, risk factors and prevention. Future researches on the perioperative management and outcomes of the fracture patients may be popular. However, the unified definition and mechanism of rebound pain should be laid more importance.

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## Disclosure

The authors declare no potential conflicts of interest in this work.

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