

# Worldwide research on abdominal compartment syndrome: bibliometric analysis of scientific literature (1993-2022)

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## ABSTRACT

Continuing studies related to Abdominal Compartment Syndrome (ACS) is imperative in terms of its significant effect on morbidity and mortality rates. To establish bibliometric analysis as a comprehensive review of ACS literature. The process encompasses many phases, such as delineating search terms, beginning and refining search results, creating preliminary statistics from the data, and performing data evaluation. Scopus database was selected as the primary source, and VOSviewer software was used to visualize author networks, country affiliations, journal affiliations, and keyword associations. The analysis was conducted on January 16th, 2023, and yielded a total of 855 documents spanning the period from 1993 to 2022. Studies on ACS showed an annual increase, but it has not yet reached a mature stage. United States leads the world in terms of the highest number of publications, h-index, citations, and the involvement of renowned authors and organizations. Through an analysis of less frequently used keywords, this study identified potential themes for future investigation, including histopathology, biological markers, interleukin 6, alanine aminotransferase, early diagnosis, scoring systems, the severity of illness indices, clinical practices, patient monitoring, preoperative evaluations, minimally invasive surgery, inter-method comparisons, multicenter studies, follow-up investigations, systematic reviews, and meta-analyses. While publications in ACS journals are crucial, they alone are not exhaustive, necessitating further research.

**Keywords:** Abdominal compartment syndrome, Bibliometric analysis, Digestive surgery, Research trend, Scopus.

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## Introduction

Abdominal Compartment Syndrome (ACS) is characterized as any organ dysfunction resulting from intraabdominal hypertension (IAH) or intraabdominal pressure (IAP) equal to or exceeding 12 mmHg, as defined by World Society of Abdominal Compartment Syndrome (WSACS) (1). In the majority of cases, ACS develops when IAP exceeds 20 mmHg (2). WSACS published treatment guidelines for ACS (3). Morbidity and mortality associated with ACS are incredibly high

(4, 5). Between 75% and 90% of individuals with ACS report an elevated risk of mortality (6). However, there are few relevant suggestions for ACS treatment, especially in the context of ordinary clinical practice. Therefore, current research on ACS are vital to better our knowledge and, as a result, improve management options. Bibliometrics is the subfield of information science that examined the metadata associated with published materials (7–9). It is applied to assess the research contributions made by countries, institutions, authors, and journals. At present, it is steadily emerging as a pivotal research domain in various fields (10). This study used the analytical tool VOSviewer (11) for conducting a bibliometric analysis. We analyzed publication's keywords, co-citations, countries/territories,

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publication numbers, institutions, authors, and journals. This information is used to quantitatively and intuitively characterize published works, thereby offering a comprehensive overview of the most significant contributions to a specific field of study. The citation index of a document signified the cumulative number of citations the paper garnered over time and can be construed as a surrogate indicator of its overall influence within the subject it pertains to (12).

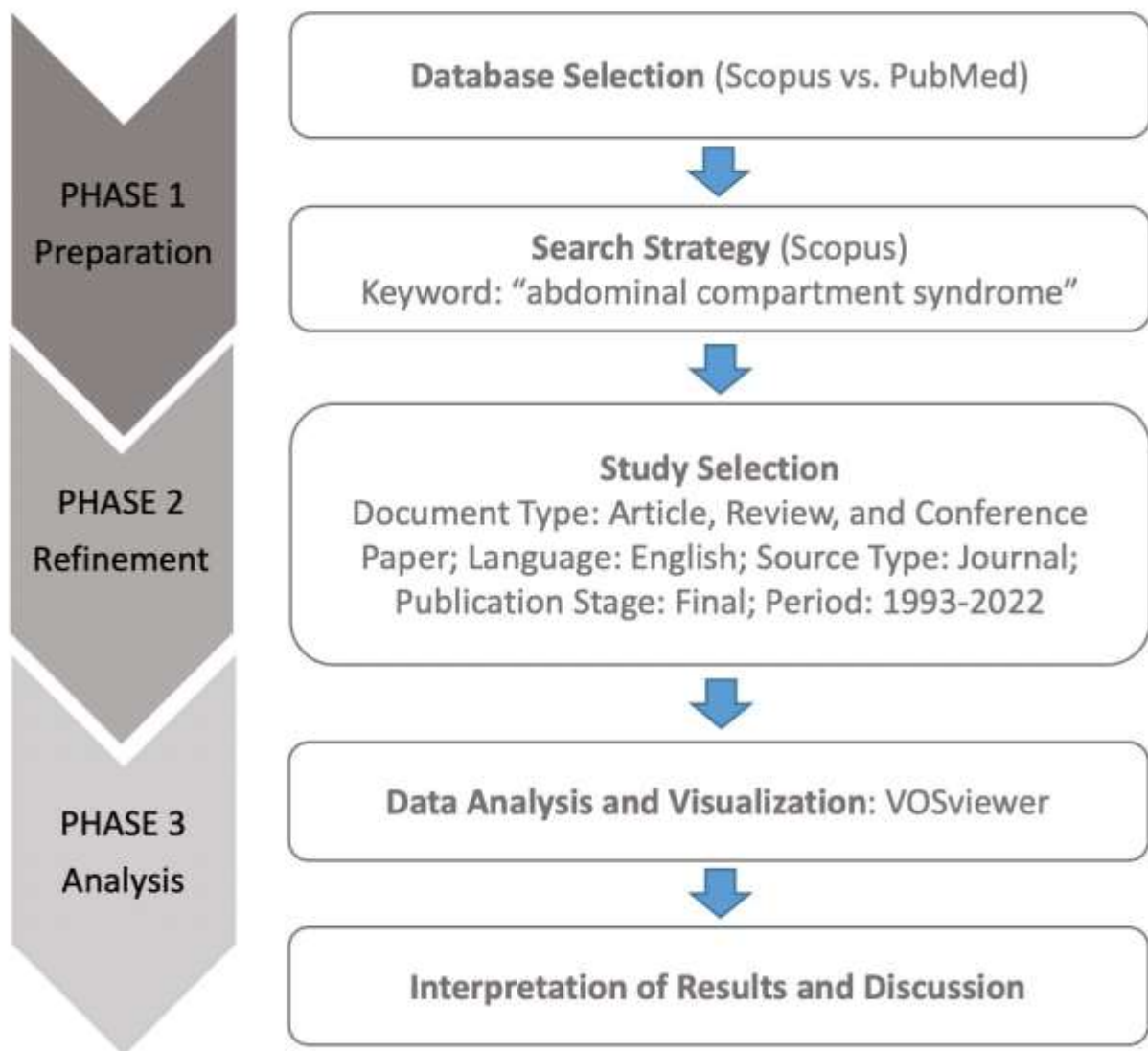
To date, there was no bibliometric analysis of the research outputs in this field. As a result, a series of scientometric and visual studies were performed to create a complete knowledge map for ACS in order to understand future research orientations using

bibliometric analysis. The primary objective was to examine the quantity distribution of ACS studies due to the number of annual publications; the country or territories with the most publications, as well as its h-index and citations; the authors, institutions, and journals with the most publications; and the cited references. Subsequently, utilizing keyword analysis, the second objective of this study was to identify research gaps and potential future research topics in the ACS field.

## Methods

### Data sources and search strategy

Before selecting the database, a comparative



**Figure 1.** Study methodology

analysis was conducted between Scopus and PubMed to identify the most suitable source for a comprehensive bibliometric assessment. An initial search for "abdominal compartment syndrome" yielded 1,860 results in PubMed and 3,254 entries in Scopus. Scopus was considered the more complete resource since it offered a larger dataset. Moreover, since VOSviewer (version 1.6.18), our chosen visualization software, is limited to processing a single database at a time, Scopus was selected as the primary data source based on its higher yield and extensive coverage.

To mitigate potential bias stemming from daily database updates, all searches for "abdominal compartment syndrome" were conducted on January 16th, 2023. We restricted the selection to studies published in English, at the final stage of publication, open-access literature, and published within the last 30 years (1993-2022). This research only included articles, reviews, and conference papers published in journals. Subsequently, we evaluated all papers that fulfilled our criteria based on their title and abstract, excluding any unnecessary ones. In total, 855 studies were downloaded and analyzed. We collected information about article's author, journal, institution, country, and keywords. The methodology of this study is visualized in Figure 1.

## Data analysis and visualization

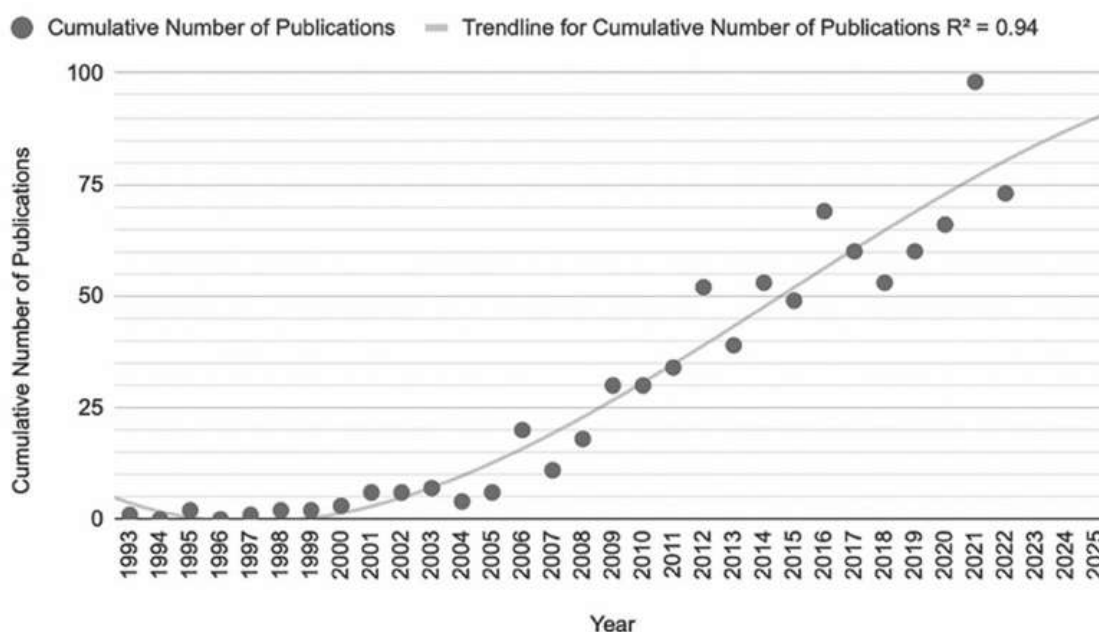
The downloaded data were analyzed using the

literature analysis report from the Scopus database. For further examination of publication output, VOSviewer (version 1.6.18) was employed. VOSviewer is a visualization software renowned for its cluster analysis capabilities and excellent data visualization (11, 13, 14). Connections within the bibliometric data may be seen thanks to the outputs' presentation as nodes and links. The distance between each node indicates the degree of correlation between the phrases that are presented, and the size of nodes is directly correlated with their frequency of occurrence (15). The visualization process was performed following previous studies procedure (16–20).

## Results

### Distributions of annual publications

Out of a total of 3,254 papers, only 855 met our criteria. The overall number of publications is illustrated in Figure 2 by year, depicting a noticeable increase from 1993 to 2022, where the count grew from one article to 69 articles. The initial publications emerged in 1993 and 1995. We found a substantial association between publication year and number of publications in ACS research using polynomial curve fitting (coefficient of determination ( $R^2$ ) = 0.94). Based on this curve fitting analysis, it is projected that by 2025, the number of publications will surpass 90.



**Figure 2.** The trend of publications growth in the ACS study methodology

### Distributions of country or territories with most publications

ACS analysis included 855 papers from 78 countries or territories. As shown in Figure 3A, the United States published the most articles (221), followed by United Kingdom (76), China (66), and Germany (49). Nevertheless, the total number of publications originating from the Asian continent is only 207 (24.21 percent of all research). China and Japan are the only Asian nations to rank in the top 10. Currently, there exists just one research from Indonesia, which is a case report about newborns with stomach perforation who had delayed laparotomy and gastric repair (21).

### Citations and h-index analysis

A Scopus investigation showed that between 1993 and 2022, ACS-related articles were cited 21,317 times (18,459 times without self-citations). Among top 10 most prolific countries/territories, the United States has the highest h-index (46) and the total number of citations (10,477). Even though Switzerland publishes fewer publications than any of other top 10 countries, the overall number of citations is significantly higher. Figure 3B depicts the top ten countries and territories alongside an H-index analysis.

### Distributions of authors with most

### publications

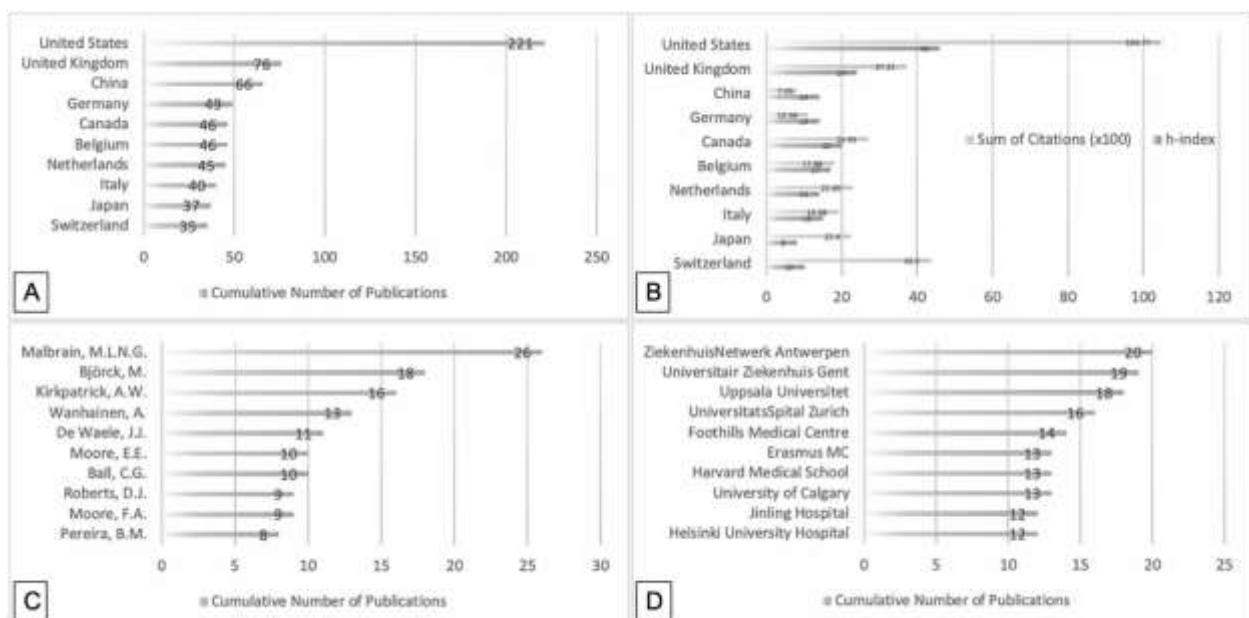
Malbrain, MLNG published 26 publications out of a total of 855 articles. Bjorck, M., who has published 18 works, is in second place, followed by Kirkpatrick, A.W., who published 16 works. The latter authors, Wanhainen, A. and De Waele, J.J., produced fewer works, with 13 and 11, respectively. Figure 3C depicts the distribution of the ten authors with the greatest number of publications in the ACS study.

### Distributions of institutions with most publications

ZiekenhuisNetwerk Antwerpen has 20 articles related to ACS, securing the top spot. Universitair Ziekenhuis Gent follows closely with 19 ACS-related publications, ranking second. Uppsala University is in third place with 18 publications, followed by UniversitätsSpital Zurich with 16 publications, as well as Foothills Medical Center and Uppsala University with 14 publications each. Figure 3D illustrates the distribution of the top 10 institutions with the most publications in ACS analysis.

### Distributions of source journals

Based on the data retrieved, 160 journals received publications about the ACS study. Journal of Vascular Surgery, a Unites States journal, was the most prolific,



**Figure 3.** Distribution of abdominal compartment syndrome-related publications. (A) Distribution of top ten countries/territories with the most significant number of publications; (B) Analysis of top ten countries/territories by citations and H-index; (C) Distribution of top ten authors with most publications; (D) Distribution of top ten institutions with most publications



The research hotspots in ACS were identified by analyzing co-occurrence of frequent keywords. A minimum of 15 co-occurrences was set as the threshold for a keyword to be considered. Among 7116 ACS-related keywords initially retrieved, only 229 met this minimum requirement, after excluding unrelated keywords. The findings were subsequently presented using frequently occurring terms through a bibliometric analysis. The terms that shared similarities were further divided into five clusters, which are represented in Figure 4 as red, green, blue, yellow, and purple, respectively. The size of the nodes in the figure is proportional to their frequency of occurrence. Table 2 provides top 10 keywords for each cluster.

Figure 5 presents an overlay visualization of ACS study over the years, spanning from 1993 to 2022. In the early years of ACS research, pressure measurement (average publication year (APY) = 2011.1667), abdominal injury (APY = 2011.0909), and surgical technique (APY = 2012.0909) were the most prevalent themes. More recently, infant (APY = 2018.5), disease exacerbation (APY = 2019.4118), and clinical outcome (APY = 2019.7949) have become increasingly prominent keywords.

Figure 6 provides a density visualization that depicts the scope of ACS research within specific areas. The density of an item determines whether or not keywords are present in the color-coded representation. The study

topic is still in its early phases and necessitates additional research in future studies, as indicated by the indistinct hue of keywords with the lowest frequency. The examples include histopathology, biological marker, interleukin 6, alanine aminotransferase, early diagnosis, scoring system, severity of illness index, clinical practice, patient monitoring, preoperative evaluation, minimally invasive surgery, inter-method comparison, multicenter study, follow-up studies, systematic review, and meta-analysis.

Throughout entire year, only 24 systematic reviews and meta-analyses were conducted. The most influential articles were related to risk factors for intraabdominal hypertension, and abdominal compartment syndrome in adult intensive care unit patients (22), as well as the early survival benefits of endovascular repair over open repair for abdominal aortic aneurysm rupture (23). Meanwhile, the most recent papers discuss outcomes after repair of ruptured and intact abdominal aortic aneurysms (25), and describe damage-control surgery in patients with nontraumatic abdominal crises (24) as well.

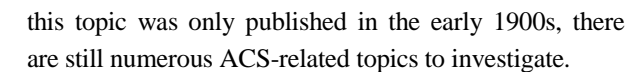
## Discussion

Considering the number of publications and the distribution of categories in ACS research, it is evident

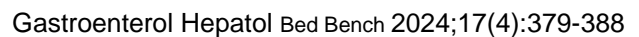
**Table 2.** Co-occurrence analysis of keywords (top 10 keywords of 5 clusters)

Rank	Cluster 1 (red)	Cluster 2 (green)	Cluster 3 (blue)	Cluster 4 (yellow)	Cluster 5 (purple)
1	abdominal compartment syndrome (707)	male (437)	intensive care (193)	adult (333)	resuscitation (83)
2	case report (273)	female (401)	mortality (187)	intraabdominal hypertension (256)	bleeding (50)
3	clinical article (219)	aged (224)	review (125)	laparotomy (237)	blood transfusion (45)
4	computer assisted tomography (168)	middle aged (196)	multiple organ failure (125)	abdominal pressure (198)	blood clotting disorder (36)
5	complication (113)	treatment outcome (164)	disease severity (101)	procedure (112)	crystalloid (31)
6	sepsis (111)	major clinical study (149)	length of stay (84)	intraabdominal pressure (103)	trauma (27)
7	hospitalization (109)	controlled study (144)	critical illness (77)	Pathophysiology (100)	critical care (26)
8	artificial ventilation (103)	retrospective study (142)	acute pancreatitis (71)	decompression surgery (95)	acidosis (25)
9	acute kidney injury (91)	risk factor (137)	pancreatitis (62)	prospective study (80)	glasgow coma scale (23)
10	abdominal distension (86)	postoperative complication (120)	morbidity (53)	surgical technique (74)	hemorrhagic shock (22)





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this topic was only published in the early 1900s, there are still numerous ACS-related topics to investigate.

Analyzing the results for countries/regions and institutions, it becomes apparent that the United States, the United Kingdom, China, and Germany are the leading producers of research in this field. In contrast, Asia contributed only 24.21% of all published research, with China and Japan being the only Asian countries in top 10 with a significant number of publications. In 2021, Indonesia published the article titled "Delayed laparotomy and gastric repair in gastric perforation: a case report in a neonatal patient." When examining the countries with the highest number of publications, the bibliometric study shows that there are no African countries in the top ten, while six European countries dominate the list. Between 1993 and 2022, ACS-related articles were cited 21,317 times, and regarding the total number of citations and h-index, the United States leads in both categories.

Despite having the fewest publications among the top 10 nations, Switzerland has significantly more total citations than all other top 10 nations except the United States. Among all countries, the United States had the highest H-index and published the most articles on ACS. Although the United States allocates a lower percentage of its GDP to social services such as healthcare, it is important to note that the country has the highest gross domestic product (GDP), which provides a sufficient amount of resources for clinical research (26–28). Switzerland produced numerous high-quality studies with strong financial support and government assistance, thanks to various programs and policies implemented by Swiss federal government since 2015. Additionally, research initiatives generously supported by European Research Council are more likely to succeed when performed in countries, such as Switzerland (29, 30).

ZiekenhuisNetwerk Antwerpen was the most productive institution for publishing ACS-related articles with 20 articles, while Malbrain was the most prolific author with 26 publications. There are 160 journals that published about ACS study, including the Journal of Vascular Surgery, which has 33 articles. The article with the most citations is "American College of Gastroenterology Guideline: Management of acute pancreatitis" published in American Journal of Gastroenterology. However, the article with the most citations per year is "The Society for Vascular Surgery Practice Guidelines on The Care of Patients with an

Abdominal Aortic Aneurysm" published in the Journal of Vascular Surgery.

This could be attributed to the fact that abdominal aortic aneurysm is one of the primary causes of ACS, and endovascular repair is one of the most prevalent interventions for ACS (31). Acute pancreatitis and other abdominal disorders continue to be among the principal causes of ACS, despite not being surgical or postoperative in nature. Subacute IAH is a kind of acute pancreatitis that often manifests in severe acute pancreatitis and develops progressively over days (32). By analyzing co-occurrence of frequent keywords, research hotspots were identified and divided into five clusters containing keywords with similar characteristics. Subsequently, undifferentiated keywords indicate that the research topic is still in the development stages and requires further investigation in future studies.

When conducted correctly and systematically, systematic reviews and meta-analyses remained the highest-quality study designs (33). The purpose of systematic reviews was to provide answers to clinical queries based on evidence synthesis from multiple distinct studies. Systematic reviews and meta-analyses can address various research questions, including those related to diagnosis, treatment, prognosis, education, and quality improvement. Only 24 systematic review and meta-analysis papers were published out of 855 investigations. It is crucial to do high-quality research to close the information gaps since ACS is becoming one of the most prevalent discoveries, especially among critically ill patients with increased mortality, especially those with higher-grade ACS (34).

## Conclusion

The research yielded a total of 855 documents spanning from 1993 to 2022. The volume of research on ACS has grown annually, but has not yet reached a mature stage. United States leads in terms of the number of publications, the h-index, the number of citations, and the participation of top authors and organizations worldwide. Furthermore, the analysis of keywords with lower occurrence frequency in this study identified potential topics for future research, such as histopathology, biological markers, interleukin 6, alanine aminotransferase, early diagnosis, scoring systems, severity of illness indices, clinical practices, patient monitoring, preoperative evaluation, minimally



invasive surgery, inter-method comparisons, multicenter studies, follow-up studies, systematic reviews, and meta-analyses. It is important to note that the fact that only datasets from the Scopus database were utilized as resources limits the study's reach. In order to increase the breadth and depth of their study, it is advised that future studies make use of a range of electronic resources.

## Conflict of interests

There is no conflict of interest for authors of this article.

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