



Ultrasonography in the intensive care unit: a bibliometrics analysis

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Background: Ultrasonography is widely used in critical care practice. The status of related studies remains unclear. The purpose of this study is to analyze current literature investigating the use of ultrasound in critical care units by using bibliometric analysis.

Methods: The Science Citation Index Expanded (SCI-E) database was used for data retrieval. The search formula for literature retrieval was “ultrasound” OR “ultrasonography” AND “intensive care unit” OR “critical care unit” OR “intensive care” OR “critical care”. The bibliometric software package of R software was used to analyze the results. Information of related literatures were analyzed.

Results: Finally, 3,715 articles were included. The number of published articles and the number of references increased annually. The research fields included medical imaging, critical care medicine, cardiology, etc. The United States has published more documents in this field than other countries and has shown the highest rate of cooperation with other countries. Among the top 10 research institutions with the largest number of publications, 5 are from France and 3 are from the United States. There are many authors from China in the top 10 published studies. Among the top 10 journals with the largest number of published articles, 5 journals are top journals in the field of critical care medicine. Among the top 10 keywords, there are 5 of ultrasound specialty and 2 of critical care medicine.

Conclusions: Researches on the use of ultrasound in critical care units are mainly concentrated in several developed countries in Europe and the United States. Chinese research institutions should perform more studies in this field and increase cooperation with institutions from other countries.

Keywords: Critical care; ultrasound; ultrasonography; bibliometric analysis; cooperation

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Introduction

In recent decades, critical care medicine has rapidly developed. In the intensive care unit (ICU), various instruments can be used to monitor and treat patients (1,2). These instruments can obtain real-time and accurate

physiological parameters, which has important clinical reference value for understanding changes in the patient's condition and timely adjusting the treatment plan (3,4). However, some critically ill patients need advanced imaging information during hospitalization in the ICU that may be missed by physical examination. Moreover, image guidance

can improve the success rate and shorten the operation time of some procedures, such as blood vessel puncture and catheter implantation (5). Whether by providing accurate diagnostic information in time or by guiding a procedure, ultrasound can contribute to the improvement of the medical treatment and prognosis of critically ill patients. Ultrasound has several advantages over other imaging modalities, including the ability to perform bedside real-time examinations and assess function and pathological changes and of most body organs (6,7). Therefore, in recent years, ultrasonic examination has been widely performed in ICUs, and an increasing amount of relevant research has been published (8). There are several indications of ultrasound in the ICU, including cardiovascular system examination, chest and abdominal fluid evaluation, real-time ultrasound guidance (6,7). Some studies have shown that transthoracic echocardiography can reduce the risk of 28-day death in critically ill patients (9,10). A number of studies have shown that ultrasound examination has important clinical value in the ICU (11-13). In recent years, researchers have also published a large number of reviews, where they summarized and analyzed the application of ultrasonic examination in the ICU. However, there is no systematic review on the overall status of relevant research on the application of ultrasound in the ICU and the status of related studies remains unclear. Bibliometrics searches the literature of a specific subject and then statistically analyzes the relevant information of the literature, such as the country conducting the research, the research institution, and the author of the paper. Through analysis, it can reflect the distribution characteristics of relevant research within a specific time and a specific geographical

region. It can also reflect the research focus of this field through keyword analysis. The purpose of this study is to summarize the state of research on ultrasound application in the ICU through bibliometric analysis for investigators.

Methods

Data source

The online Science Citation Index Expanded (SCI-E) database in the Web of Science Core Collection (WOSCC) was used for data retrieval, since it is the most common used database in medical research.

Search strategy

In this study, the literature was searched by applying the following keywords: “ultrasound” OR “ultrasonography” AND “intensive care unit” OR “critical care unit” OR “intensive care” OR “critical care” in a fuzzy method. Literature retrieved by using the above keywords and published were included without specific time limit.

Analysis

All records and references of the search results were exported in plain text format. For literatures related to the utility and research of ultrasonography in critical care practice, numbers of documents, countries, institutions were analyzed, and the relationship (centrality score) between countries, institutions and authors were also analyzed. Related journals, in which those searched literatures were published were also analyzed. Keywords used in these literatures was analyzed.

Statistical analysis

Excel software was used to chart the trend of the number of published documents and the number of cited documents in this field each year. Qualitative data are expressed in terms of quantity and percentage. The information of related literatures was analyzed using the bibliometric software package of R software.

Results

General information

A total of 3,991 relevant research literature records were

Highlight box

Key findings

- Researches on the use of ultrasound in critical care units are mainly concentrated in several developed countries in Europe and the United States.

What is known and what is new?

- Ultrasonography is widely used in critical care practice.
- This study described the current status of related studies on the utility and research of ultrasonography in critical care practice.

What is the implication, and what should change now?

- Chinese research institutions should perform more studies in this field and increase cooperation with institutions from other countries.

retrieved in this study, including 276 duplicate records. After removing duplicate records, 3,715 studies were finally included—among them: 244 clinical studies, 80 randomized clinical trials (RCT) studies, 105 systematic reviews, 267 case reports, 159 conference abstracts, and 57 online publications published in advance. *Table 1* summarizes the types of publications. The analysis results show that the number of published documents is basically increasing year by year (*Figure 1*). Moreover, the number of citations in the literature also shows an increasing trend year by year (*Figure 1*). These documents were cited 86,771 times, with an average of 23.4 times for each document. The analysis of

research fields involved in these studies (*Table 2*) shows that the most common fields are medical imaging, critical care medicine and cardiology.

Analysis of countries and institutions

The analysis of the source countries of the literature shows that the number of studies published in this field in the United States is significantly higher than that published in other countries (*Figure 2*). The higher the score, the more research cooperation there is between the country and other countries. The analysis results (*Table 3*) show that the United States has the highest centrality score; that is, the United States has the highest rate of cooperation with other countries, followed by the United Kingdom, France and other European countries, in terms of performing ultrasounds on critically ill patients. However, China did not rank in the top 10 in terms of the number of published documents and the centrality score. The analysis of the research institutions that published literature about ultrasound in critical care units shows that among the top 10 research institutions (*Table 4*), 5 are in France, 3 are in the United States, 1 in the United Kingdom and 1 in Canada. The centrality score results reflecting the level of cooperation between research institutions (*Table 5*) shows that Udice French Research Universities has more cooperation with other research institutions, followed by Assistance Public Hopitaux Paris Aphp and Institut National De La Sante Et De La Recherche Medical. China

Table 1 Type of publications

Type	Records	Percentage (%)
Original articles	3,356	90.34
Review	554	14.91
Case report	267	7.19
Clinical trial	244	6.57
Meeting paper	203	5.46
Abstract	159	4.28
Editorials	121	3.26
Letters	83	2.23
Dataset	73	1.97
Online first	57	1.53

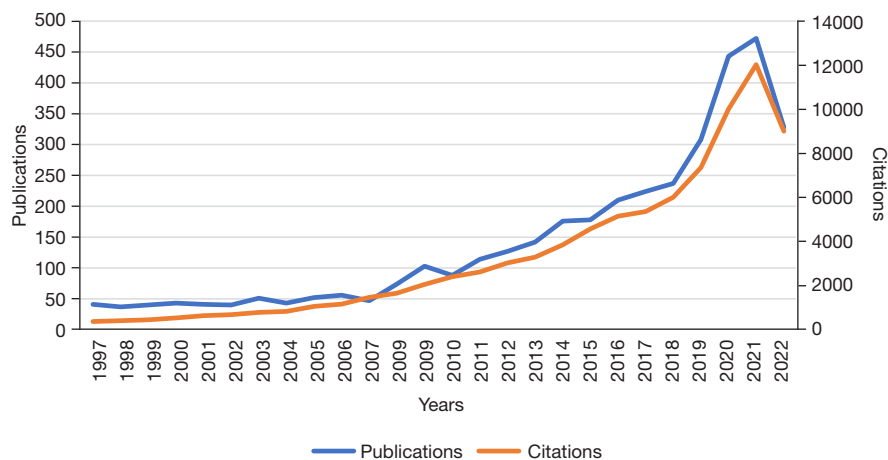
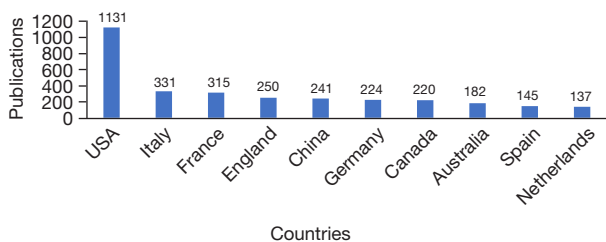


Figure 1 Annual trends of publications and citations.

Table 2 Research fields of publications

Direction	Records	Percentage (%)
Radiology, nuclear medicine, medical imaging	2,245	60.43
Critical care medicine	1,739	46.81
Cardiovascular system cardiology	1,606	43.23
General internal medicine	1,554	41.83
Pediatrics	1,482	39.89
Health care sciences services	1,196	32.19
Respiratory system	1,100	29.61
Pathology	1,001	26.94
Surgery	908	24.44
Anesthesiology	823	22.15

**Figure 2** Top 10 countries in publications.**Table 3** Centrality of countries

Ranks	Countries	Centrality
1	USA	0.41
2	United Kingdom	0.27
3	France	0.25
4	Canada	0.24
5	Germany	0.20
6	The Netherlands	0.18
7	Italy	0.17
8	Japan	0.10
9	Spain	0.09
10	Australia	0.08

Table 4 Top 10 institutes by number of publications

Ranks	Institute	Records	Percentage (%)
1	Udice French Research Universities	182	4.90
2	Assistance Publique Hopitaux Paris Aphp	175	4.71
3	Institut National De La Sante Et De La Recherche Medicale	104	2.80
4	Harvard University	91	2.45
5	University of Toronto	90	2.42
6	Universite Paris Cite	73	1.97
7	University of California	72	1.94
8	University of London	72	1.94
9	Sorbonne Universite	61	1.64
10	University of Pennsylvania	59	1.59

Table 5 Top 10 institutes by centrality

Ranks	Institutions	Centrality
1	Udice French Research Universities	0.39
2	Assistance Publique Hopitaux Paris	0.36
3	Institute National De La Sante Et De La Recherche Medicale	0.35
4	Harvard University	0.28
5	University of Toronto	0.23
6	Universite Paris Cite	0.22
7	University of California	0.19
8	University of London	0.16
9	Sorbonne Universite	0.15
10	University of Pennsylvania	0.12

still has no research institutions in the top 10. We also analyzed the number of papers published by author groups (*Table 6*), and the results showed that IEEE (American Institute of Electrical and Electronic Engineers) and the Chinese Severe Ultrasound Research Group published the highest number of papers.

Table 6 Top 10 author groups

Ranks	Group	Records	Percentage (%)
1	Institute of Electrical and Electronic Engineers	9	0.24
2	Chinese Critical Ultrasound Study Group	8	0.22
3	Australian And New Zealand Neonatal Network	4	0.11
4	Canadian Critical Care Trials Group	4	0.11
5	Canadian Neonatal Network	4	0.11
6	Elgan Study Investigators	4	0.11
7	Canadian Critical Care Trials Grp	3	0.08
8	Darts Consortium	2	0.05
9	Epo Tbi Investigators	2	0.05
10	Eurus Brain Group	2	0.05

Table 7 Top 10 authors by number of publications

Ranks	Authors	Records	Percentage (%)
1	X Wang	24	0.65
2	J Liu	23	0.62
3	D Karakitsos	18	0.48
4	D Lichtenstein	18	0.48
5	M Dres	17	0.46
6	Giovanni Volpicelli	17	0.46
7	Yin Wanhong	17	0.46
8	LS De Vries	16	0.43
9	B Bouhemad	15	0.40
10	Dawei Liu	14	0.38

Author analysis

The analysis of the author groups (*Table 7*) shows that many authors in China have been included in the top 10 for the number of published articles, among which Xiaoting Wang and Jihai Liu have published 24 and 23 articles, respectively, ranking first and second among all authors. The other researchers in the top 10 are from Italy, France

Table 8 Top 10 authors by centrality on critical care and ultrasound

Ranks	Authors	Centrality
1	X Wang	0.32
2	J Liu	0.29
3	D Karakitsos	0.28
4	D Lichtenstein	0.27
5	M Dres	0.24
6	G Volpicelli	0.17
7	LS De Vries	0.17
8	B Bouhemad	0.15
9	W Yin	0.14
10	F Mojoli	0.13

and the Netherlands. *Table 8* summarizes the analysis of the researchers' centrality scores.

Journal analysis

The journal analysis (*Table 9*) shows that the journals with the highest number of publications on critical care and ultrasound research are Intensive Care Medicine, followed by Critical Care Medicine and Critical Care. Among the top 10 journals with the largest number of published articles, 5 journals are authoritative journals in the field of critical care medicine. We also showed that among the top 10 journals, there are 4 in the field of obstetrics and gynecology.

Keywords analysis

We analyzed the keywords used in all the included studies, and the results showed that (*Table 10*) the most frequently used keywords in these studies were "ultrasound", followed by "critical care", "ultrasonography", etc. Among the top 10 keywords, there are six nouns of ultrasound specialty (ultrasound, ultrasonography, point-of-care, transthoracic echocardiography, bedside ultrasound and echocardiography).

Summary of main indication of ultrasonography

We summarized the main indication of the utility of ultrasonography in ICU practice in *Table 11*.

Table 9 Top 10 journals by publications

Ranks	Journals	Publications	Percentage (%)	2022 IF
1	<i>Intensive Care Medicine</i>	113	3.04	41.787
2	<i>Critical Care Medicine</i>	87	2.34	9.296
3	<i>Critical Care</i>	77	2.07	19.334
4	<i>Journal of Ultrasound in Medicine</i>	65	1.75	2.754
5	<i>Ultrasound in Obstetrics Gynecology</i>	64	1.72	8.678
6	<i>Journal of Critical Care</i>	63	1.70	4.298
7	<i>Journal of Maternal Fetal Neonatal Medicine</i>	53	1.43	2.323
8	<i>American Journal of Obstetrics and Gynecology</i>	47	1.27	10.693
9	<i>Pediatric Critical Care Medicine</i>	44	1.18	3.971
10	<i>American Journal of Perinatology</i>	43	1.16	3.079

IF, impact factor.

Table 10 Analysis of keywords

Keywords	Frequency	Percentage (%)
Ultrasound	2,384	64.17
Critical care	1,879	50.58
Ultrasonography	925	24.90
Point-of-care	718	19.33
Transthoracic echocardiography	626	16.85
Lung	542	14.59
Trauma	437	11.76
Bedside ultrasound	235	6.33
Intensive care	221	5.95
Echocardiography	194	5.22

Discussion

Ultrasound imaging has indeed changed the practice of intensive care medicine. The results of this study show that the application of ultrasound in critical care has shown an obvious growth trend in recent years and has received extensive attention. Many studies have been published in important journals of critical care medicine. The analysis of the distribution of countries and research institutions conducting research shows that the United States has significantly more research in this field than other countries. Moreover, at the national level, the United States have shown to be more cooperative with other countries. The

Table 11 The main indication of the utility of ultrasonography in ICU practice

Indication	Utility
Circulation unstable	Assessment of inferior vena cava
	Assessment of cardiac function
	Assessment of pericardium
	Assessment of pulmonary edema
	Assessment of abdominal hemorrhage
Dyspnea/hypoxemia	Assessment of aorta
	Assessment of lung
Elevated intracranial pressure	Assessment of diaphragm function
	Assessment of optic nerve sheath diameter
Acute kidney injury	Differential diagnosis
Enteral nutrition	Assessment of gastrointestinal function
	Assessment of catheter implantation
Infection	Detection of infected focus

ICU, intensive care unit.

research institutions with the largest number of published documents are Udice French Research Universities and Assistance Publique Hopitaux Paris Aphp from France. The authors analysis shows that in this field, some research has been completed by author groups, including IEEE and the Chinese Critical Ultrasound Study Group. Although some

authors from China have published the largest number of papers, they have led relatively few cooperative studies. In terms of journals, the major journals are those of critical care medicine and ultrasound, and a large number of studies are published in authoritative journals. The keyword analysis showed that the keywords related to ultrasound and critical care medicine were used more frequently.

Ultrasonography, especially bedside ultrasound, has important clinical value for examining critically-ill patients. In the ICU, ultrasound is mainly used in the following situations: to evaluate the structural and functional changes of the heart; understand the hemodynamic state of the patient; evaluate pneumonia and pulmonary edema; evaluate the morphological changes and functions of abdominal organs; evaluate whether there is bleeding and effusion in the abdominal cavity; and assess the wound tissue. Bedside ultrasound can be used to monitor the inferior vena cava collapse index (IVC-CI) in order to evaluate the right heart pressure and circulation volume status (14). Many studies have shown that the IVC-CI has a good correlation with the central venous pressure (CVP) and pulmonary thromboembolism (15,16). Bedside ultrasound plays a key role in rescue after resuscitation by dynamically monitoring changes in the cardiac structure (17). Another study showed that ultrasound has high sensitivity and specificity in the diagnosis of acute pulmonary embolism (18). Transthoracic echocardiography can quickly and accurately observe changes in the cardiac structure and function and judge whether the heart stops, whether there is cardiac rupture, pericardial effusion (blood), etc. It can definitively have an influence on the treatment approach (9,19,20). Adult respiratory distress syndrome often leads to acute cor pulmonale (21). Previous studies found that 3 days before patients with acute respiratory distress syndrome (ARDS) are placed under mechanical ventilation, cardiac ultrasound examination can assist in accurately adjusting the mechanical ventilation parameters and reducing the incidence of acute cor pulmonale and overall mortality (22,23). Off-line cardiac ultrasound examination is beneficial for risk assessment in these patients (24). Other research results show that the accuracy of lung ultrasound in diagnosing severe pneumonia is higher than that of procalcitonin and C reactive protein—therefore, ultrasound can be used as a reference index for diagnosing pneumonia that can be controlled and prevented early. Relevant studies have shown that the lung ultrasound score has a high diagnostic efficiency in detecting novel coronavirus pneumonia in patients with ARDS and can

be used as an important reference index for diagnosis (25-27). Besides, endobronchial ultrasonography has been successfully used in the ICU and helped clinicians to better understand and treat bronchial problems (28).

Ultrasound also has important clinical value in monitoring and evaluating the condition of patients with severe trauma. The condition of some trauma patients may be aggravated by frequent movement due to their severe injuries. Bedside ultrasound can be used to evaluate these patients in real time. Focused assessment with sonography in trauma (FAST) and extended focused assessment with sonography in trauma (E-FAST) are bedside ultrasound examination methods that are suitable for rapid assessment of internal bleeding in trauma patients (29-31). Some studies have shown that for patients with severe trauma, ultrasonic examination is helpful in determining the patient transfer facility, thus affecting the survival rate of trauma patients (32,33). Bedside ultrasound can more intuitively show the two-dimensional (2D) shape and structure of thoracic and abdominal organs and large vessels, and abnormal changes in the hemodynamic situation can be clearly understood using color Doppler imaging (34).

In addition to the examination and evaluation of important organs, ultrasound can also assist blood vessel puncture, tissue puncture, and various catheterizations (35-38). In critically-ill patients, there may be venous collapse, tissue edema, and tissue trauma, which can lead to difficulties in puncture or catheter placement. Ultrasound can show the anatomical morphology of the target blood vessels and pipes and the position of the head of the puncture needle or catheter in real time, guiding the operator to adjust in real time to improve the success rate of puncture or catheterization (39,40).

Through the statistical analysis of the literature related to the application of ultrasound in the practice of critical care medicine, this study shows the state of current research in this field, including the distribution of countries conducting research, the distribution of research institutions, the distribution of authors, the cooperation in research, the characteristics of journals publishing relevant articles, and the use of keywords in related literature. There are some limitations in this study. First, this study uses the keyword retrieval strategy. In a few studies, although researchers assessed the role of ultrasound in the practice of critical care medicine, they did not focus on ultrasound, and some relevant literature may be missing from the keyword retrieval. Second, this study is based on English literature only, and

therefore some relevant articles may have been missed.

Conclusions

Based on this bibliometrics analysis of the literatures on ultrasonography in the ICU, we found that relevant research is mainly concentrated in Europe and in the United States, and research in this field has become the center of attention. Chinese research institutions should perform more studies in this field and increase cooperation with other institutions from other countries.

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Footnote

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