Ukrainian Journal of Nephrology and Dialysis
Scientific and Practical, Medical Journal

Founder:
- National Kidney Foundation of Ukraine

ISSN 2304-0238;
eISSN 2616-7352

Journal homepage: https://ukrjnd.com.ua

Case report

doi: 10.31450/ukrjnd.4(88).2025.02

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Global research trends and collaboration networks in arteriovenous fistula bleeding for haemodialysis: A bibliometric analysis (2000–2024)

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Citation: Anggraeni N, Saryono. Global research trends and collaboration networks in arteriovenous fistula bleeding for haemodialysis: A bibliometric analysis (2000–2024). Ukr J Nephrol Dialys. 2025;4(88):9-20. doi: 10.31450/ukrjnd.4(88).2025.02.

Abstract. *Arteriovenous (AV) fistula is the gold standard for long-term haemodialysis, yet bleeding complications remain frequent, causing anemia, treatment interruption, and hospitalizations. Despite its clinical importance, research on AV fistula bleeding is fragmented across disciplines. This study provides the first global bibliometric analysis exclusively focused on AV fistula bleeding, offering a consolidated view of research trends and gaps. The present study aimed to map global research output, thematic clusters, and emerging trends in AV fistula bleeding over the past two decades.*

Methods. Publications from 2000–2025 were retrieved from Scopus and PubMed using predefined keywords via Publish or Perish. After duplicate removal and title/abstract screening, 127 English-language articles met the eligibility criteria. Data were analyzed with VOSviewer (v1.6.19) to create density, network, and overlay visualizations with a minimum threshold of five term occurrences.

Results. From an initial 3,085 records, annual output increased steadily after 2010. The United States, the United Kingdom, and China were the most productive countries, and the Journal of Vascular Access was the leading source. Thematic mapping identified four clusters: (1) clinical complications (hematoma, vascular events), (2) diagnostic and interventional strategies (angiography, embolization), (3) anatomical considerations (vein selection, puncture site), and (4) outcome-based evaluations (patency, safety, quality). Density maps showed persistent focus on hematoma and vascular complications, while overlay maps indicated a post-2020 shift toward patient-centered outcomes and methodological rigor.

Conclusions. Research on AV fistula bleeding has progressed from technical and anatomical themes to patient-safety and quality-of-care priorities. These findings underpin the need for standardized bleeding-management protocols and multidisciplinary collaboration to improve prevention and clinical outcomes.

Keywords: *arteriovenous fistula, bleeding complications, haemodialysis, bibliometric analysis, vascular access.*

Article history:
Received September 06, 2025
Received in revised form September 23, 2025
Accepted October 04, 2025

Conflict of interest. The authors declare no conflict of interest.

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УДК: 616.61-085.38-073.27:616.13/14–089.86]:616-06

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Глобальні тренди досліджень і наукової взаємодії щодо кровотеч з артеріовенозної фістули для гемодіалізу: бібліометричний аналіз (2000–2024)

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Резюме. *Артеріовенозна (АВ) фістула є «золотим стандартом» для забезпечення довготривалого гемодіалізу, однак ускладнення, пов'язані з кровотечами, залишаються поширеними, що призводить до анемії, переривання лікування та збільшення частоти госпіталізацій. Незважаючи на клінічну значущість цієї проблеми, наукові дослідження кровотеч з АВ фістули залишаються розрізненими між різними галузями медицини. Це дослідження є першим глобальним бібліометричним аналізом, цілком присвяченим проблемі кровотеч із АВ фістули, і пропонує узагальнений огляд тенденцій розвитку та наявних прогалин у дослідженнях. Метою роботи було здійснити картування світового наукового доробку, визначити тематичні кластери та виявити новітні напрями досліджень у цій сфері за останні два десятиліття.*

Методи. Публікації за період 2000–2025 років були відібрані з баз даних Scopus та PubMed із використанням заздалегідь визначених ключових слів через програму Publish or Perish. Після видалення дублікатів і відбору за назвою та анотацією до аналізу було включено 127 англомовних статей, що відповідали критеріям включення. Аналіз даних проводився за допомогою програмного забезпечення VOSviewer (версія 1.6.19) для побудови карт щільності, мережевих та накладних візуалізацій із мінімальним порогом у п'ять повторюваних термінів.

Результати. Із початкових 3085 записів спостерігалося поступове зростання кількості публікацій після 2010 року. Найбільшу наукову продуктивність продемонстрували США, Велика Британія та Китай, тоді як провідним джерелом публікацій став Journal of Vascular Access. Тематичне картування дало змогу виділити чотири основні кластери: 1) клінічні ускладнення (гематома, судинні події); 2) діагностичні та інтервенційні стратегії (ангіографія, емболізація); 3) анатомічні аспекти (вибір вени, місце пункції); 4) оцінка результатів лікування (прохідність, безпека, якість).

Карти щільності засвідчили стійкий науковий інтерес до тем гематом і судинних ускладнень, тоді як карти накладання відобразили зміщення фокусу після 2020 року у напрямі пацієнт-орієнтованих результатів і підвищення методологічної якості досліджень.

Висновки. Дослідження кровотеч з АВ фістули поступово еволюціонували від технічних та анатомічних аспектів до питань безпеки пацієнтів і якості медичної допомоги. Отримані результати підкреслюють потребу у розробленні стандартизованих протоколів ведення кровотеч та посиленні міждисциплінарної співпраці для поліпшення профілактики та клінічних результатів.

Ключові слова: *артеріовенозна фістула, ускладнення, кровотечі, гемодіаліз, бібліометричний аналіз, судинний доступ.*

Introduction. Arteriovenous (AV) fistula is the preferred vascular access for long-term haemodialysis because of its superior patency, lower infection risk, and overall durability compared with central venous catheters or grafts, and is therefore recommended in international clinical guidelines [**1–3**]. Despite these advantages, bleeding remains a frequent and serious complication, ranging from minor oozing to life-threatening haemorrhage that can lead to chronic anaemia, interruptions in dialysis schedules, hospital admissions, or even abandonment of the fistula and subsequent use of central venous catheters with their attendant risks of infection and central vein stenosis [**4–7**].

Research on the causes, management, and outcomes of AV fistula bleeding is dispersed across nephrology, vascular surgery, radiology, and nursing, with no comprehensive synthesis of incidence, interventions, or reporting patterns [**8–11**]. This fragmentation hampers clinicians, researchers, and policymakers in identifying evidence gaps and developing targeted interventions. Bibliometric analysis offers a robust approach to address this need by quantitatively mapping the literature and visualising interconnections among keywords, authors, and themes [**12, 13**]. Yet no bibliometric study has specifically examined AV fistula bleeding, despite the substantial clinical and economic burden: vascular-access complications affect 20–30 % of haemodialysis patients annually, with fatal haemorrhage contributing to 0.4–1.6 deaths per 1,000 patient-years and healthcare costs rising

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10–20 % in affected patients [3, 14, 15]. This study, therefore, maps the global scientific landscape of AV fistula bleeding, identifies key thematic clusters, and highlights under-explored areas using VOSviewer software [13] to guide future research and inform clinical protocols in line with the World Health Organization's patient-safety agenda and the United Nations Sustainable Development Goal 3 on good health and well-being [16].

Recent bibliometric studies have shown that this method uniquely enables mapping the evolution of research themes, visualising collaboration networks, and detecting emerging topics over extended periods. Such features cannot be achieved as effectively through systematic or scoping reviews, which focus more on synthesising content and appraising study quality. Therefore, in our investigation of global research on arteriovenous fistula (AVF) bleeding for haemodialysis (2000–2024), bibliometric analysis is particularly well suited to reveal not only what has been studied, but also how the field has developed, who the key contributors are, where the knowledge gaps lie, and which trends are emerging [17–19].

Material and methods. Design. This study utilized a quantitative bibliometric research design to analyse the trends, structure, and thematic distribution of scholarly publications related to AV fistula bleeding. Bibliometric analysis, as a scientific method, is instrumental in assessing the volume, impact, and evolution of publications within a specific research domain [20, 21]. The design adopted in this study enables the identification of knowledge hotspots, research gaps, and collaboration networks by systematically analysing publication metadata [22–24]. It does not involve human participants or clinical interventions, and thus, ethical approval was not required.

Data collection. Data were collected from Scopus and PubMed, chosen for their extensive coverage of peer-reviewed biomedical literature relevant to nephrology and vascular access. Searches were conducted using Publish or Perish software with combinations of terms such as "AV fistula bleeding," "arteriovenous fistula complication," "vascular access haemorrhage," and "haemodialysis bleeding," refined with Boolean operators.

Inclusion criteria comprised peer-reviewed articles, clinical studies, and reviews published in English between 2000 and 2025 that explicitly addressed bleeding or haemorrhage in AV fistulae. Editorials, letters, conference abstracts, and non-English papers were excluded. Retrieved records were exported in CSV and RIS formats for VOSviewer integration. Duplicates were removed manually, and titles and abstracts were screened to confirm relevance.

Grey literature sources, conference proceedings and studies not indexed in Scopus or PubMed were excluded. This restriction to peer-reviewed, indexed publications ensures data quality and consistency; however, it may introduce selection bias by omitting relevant but non-indexed evidence and could slightly underestimate the breadth of global research activity in this field.

Data analysis. The datasets were imported into VOSviewer (v.1.6.19) for bibliometric mapping and visualisation. Analyses focused on keyword co-occurrence, term frequency, thematic clustering, and temporal trends. Terms were drawn from titles and abstracts, with a minimum threshold of five occurrences to exclude infrequent items and ensure clarity.

VOSviewer (version 1.6.19) was used for bibliometric mapping. The minimum term occurrence was set to five to exclude infrequently used terms and improve clarity. The clustering resolution parameter was set at 1.0 (default value) with the minimum cluster size of five items. Normalisation of co-occurrence strength was performed using the association strength method. These settings were selected based on standard recommendations in bibliometric research to ensure both clarity and reproducibility.

Three visualisation types were produced: (1) density maps, highlighting frequent terms; (2) network maps, clustering terms by co-occurrence strength; and (3) overlay maps, displaying temporal trends. Link strength values quantified associations, with maps interpreted both quantitatively and qualitatively to identify central themes, research foci, and gaps.

The final search (15 August 2025) yielded 3,085 records (Scopus = 2,884; PubMed = 211). After duplicate removal and screening, 127 articles were eligible and 127 were included. Four thematic clusters emerged: clinical complications, diagnostic and interventional strategies, anatomical considerations, and outcome-based evaluations. Density and overlay maps showed a persistent focus on vascular complications, with a post-2020 shift towards pharmacological safety, adverse event monitoring, and long-term patency.

Future priorities include standardised bleeding-management protocols, integration of patient-reported outcomes, multidisciplinary involvement, and predictive analytics. Further work is needed on educational interventions, simulation training, and quality-of-life impacts, supporting more holistic, preventive, and personalised vascular access care.

Citation counts were not normalised across years, favouring older studies; this limitation was acknowledged. Bias was reduced through the use of two major databases, comprehensive keyword strategies, English-only inclusion (noting exclusion of non-English work), and manual verification. These measures enhanced both coverage and accuracy in mapping the global AV fistula bleeding literature.

Results. The bibliometric search yielded 3,085 records, of which 127 publications met the inclusion criteria after screening and duplicate removal (Fig. 1).

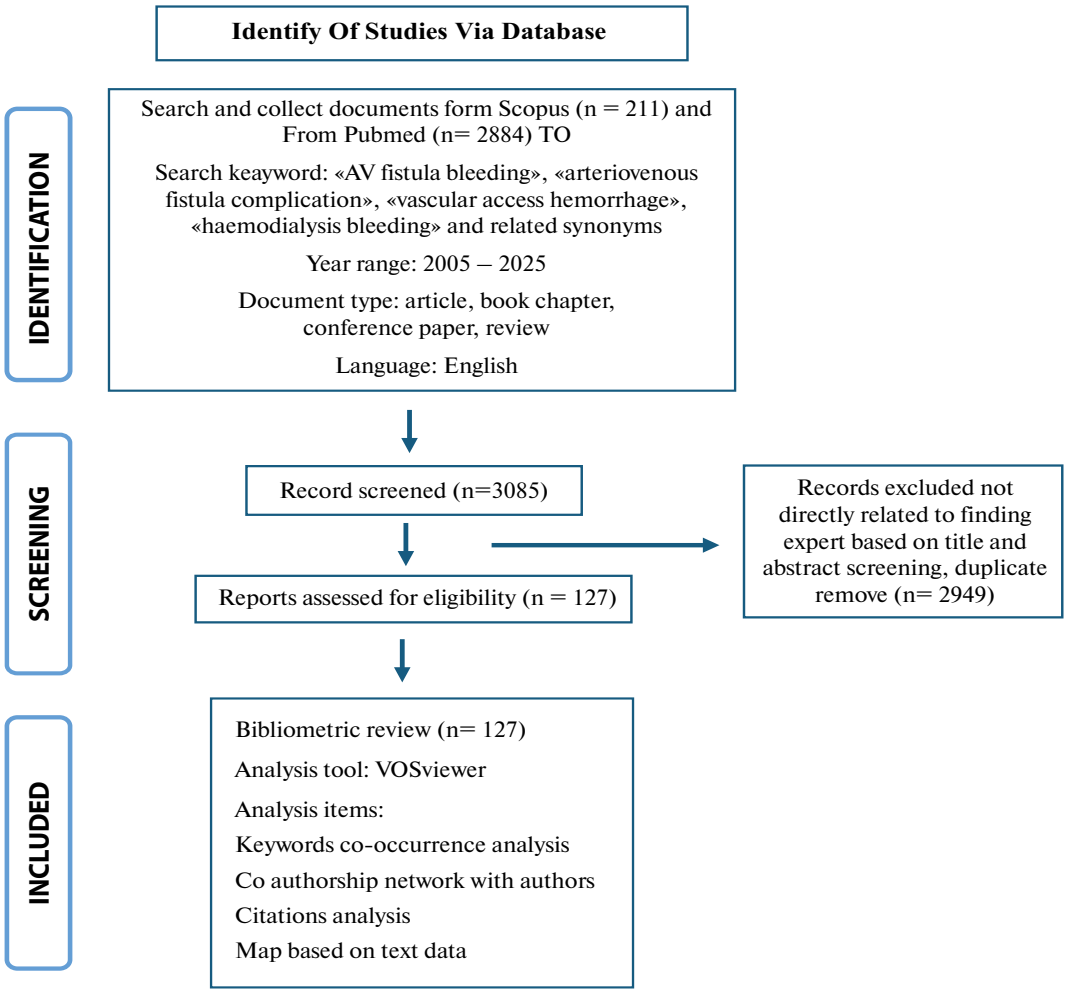

Fig. 1. Prisma Flow Diagram.

The analysis revealed a steady increase in global research activity on AV fistula bleeding, particularly after 2010, reflecting growing recognition of this issue within nephrology and vascular access care. The distribution of studies across countries and journals demonstrates both the multidisciplinary nature of the field and a gradual expansion of international collaboration. These patterns are summarised in Fig. 2, while Tables 1 and 2 highlight the most influential publications and authors that have shaped the scientific landscape of AV fistula bleeding research.

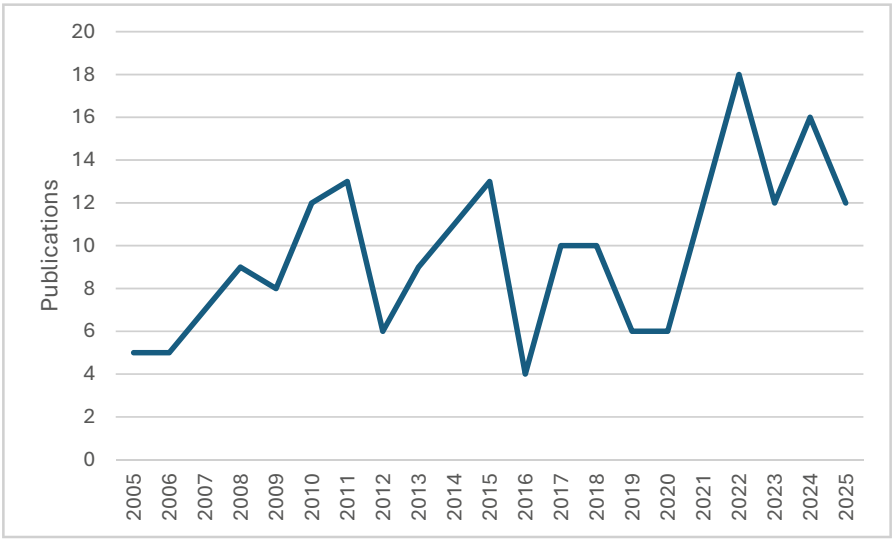

Fig. 2. Graph of publications on AV fistula bleeding from 2005 to 2025. *The graph shows an overall rise in publications on AV fistula bleeding from 2005 to 2025. Despite some temporary fluctuations, output peaked at about 18 papers in 2022 and has remained higher than in the early years, indicating sustained and growing global research interest.*

Table 1

Top 10 most cited publications AV fistula bleeding over the last two decades (from 2005 to 2025)

Rank	First Author	Citations	Year	Journal / Source	Article Title	DOI	Country	Research Focus / Theme
1	Gary Osborn	104	2014	Angiogenesis	Medical adjuvant treatment to increase patency of arteriovenous fistulae and grafts	10.1007/s10456-014-9436-3	United Kingdom	Pharmacological adjuncts to improve AV fistula and graft patency
2	Geoffrey C. Slayden	67	2008	Cochrane Database of Systematic Reviews	Secondary arteriovenous fistulas: converting prosthetic AV grafts to autogenous dialysis access	10.1002/14651858.CD002786.pub2	USA	Evidence-based conversion of prosthetic grafts to autogenous AV fistulas
3	Gevorg Stepanyan	45	2014	Journal of Interventional Cardiac Electrophysiology	Safety of new oral anticoagulants for patients undergoing atrial fibrillation ablation	10.1007/s10840-014-9888-9	USA	Evaluation of bleeding risk from novel oral anticoagulants during cardiac procedures
4	H.K. Younes	40	2011	Annals of Vascular Surgery	Transhepatic haemodialysis catheters: Functional outcome and comparison between early and late failure	10.1016/j.avsg.2010.12.020	United States	Outcomes and failure patterns of transhepatic haemodialysis catheters
5	I.N. Naazie	28	2013	American Journal of Kidney Diseases	Revision of Aneurysmal Arteriovenous Access with Immediate Use Graft Is Safe and Avoids Prolonged Use of Tunneled Haemodialysis Catheters	10.1053/j.ajkd.2013.03.028	United States	Surgical revision of aneurysmal AV access using immediate-use grafts
6	J.A. Akoh	18	2018	Clinical Research in Cardiology	Prosthetic arteriovenous grafts for haemodialysis	10.1007/s00392-018-1299-y	United Kingdom	Review of prosthetic AV grafts for haemodialysis access
7	J.A. Akoh	18	2017	Journal of Vascular Access	A 5-year audit of haemodialysis access	10.5301/jva.5000734	United Kingdom	Five-year audit of haemodialysis vascular access outcomes
8	J.D. Dale	17	2015	Cochrane Database of Systematic Reviews	Expanded Polytetrafluoroethylene-covered Stent Treatment of Angioplasty-related Extravasation during Haemodialysis Access Intervention: Technical and 180-day Patency	10.1002/14651858.CD002786.pub3	USA	Effectiveness of PTFE-covered stents in managing angioplasty-related bleeding/extravasation

Continuation of Table 1

Rank	First Author	Citations	Year	Journal / Source	Article Title	DOI	Country	Research Focus / Theme
9	J.I. Rotmans	16	2015	European Journal of Vascular and Endovascular Surgery	Haemodialysis access graft failure: Time to revisit an unmet clinical need?	10.1016/j.ejvs.2015.01.006	Netherlands	Critical review of causes and management strategies for haemodialysis graft failure
10	J.J. Fitzgibbon	15	2022	Journal of Vascular Access	Contemporary outcomes of distal radial artery ligation for access related hand ischemia	10.1177/1129729820985626	USA	Outcomes of distal radial artery ligation to treat access-related hand ischaemia

As shown in Table 1, the most frequently cited studies originated predominantly from the United States and the United Kingdom, reflecting early leadership in evidence-based approaches to vascular access management. Highly cited works focused on improving fistula patency, managing haemorrhagic complications, and evaluating interventional outcomes, indicating the clinical relevance and methodological influence of these publications.

Table 2

Top 10 authors in the co-authorship network: Documents, citations, and total link strength

Rank	Author	Documents	% Documents	Citations	% Citations	Total Link Strength	% TLS
1	Hari Bogabathina	4	13.3 %	144	29.1 %	14	16.9 %
2	Pavan Katikaneni	3	10.0 %	40	8.1 %	7	8.4 %
3	Kalgi Modi	3	10.0 %	40	8.1 %	7	8.4 %
4	Runhua Shi	2	6.7 %	35	7.1 %	6	7.2 %
5	Sampath Singireddy	2	6.7 %	30	6.1 %	6	7.2 %
6	Liam Morris	2	6.7 %	28	5.7 %	6	7.2 %
7	Abdulrahman Abdulbaki	2	6.7 %	24	4.8 %	5	6.0 %
8	Henock Zabher	2	6.7 %	22	4.4 %	5	6.0 %
9	J.A. Akoh	2	6.7 %	20	4.0 %	4	4.8 %
10	E.K. Peden	2	6.7 %	18	3.6 %	4	4.8 %
Total	–	30	100 %	501	100 %	84	100 %

The co-authorship network demonstrates a highly centralised structure. Hari Bogabathina emerges as the key hub, producing the highest proportion of publications and citations, supported by a smaller group of mid-level contributors such as Pavan Katikaneni and Kalgi Modi. The remaining authors form a more distributed periphery, indicating moderate international collaboration but a concentration of influence within a few leading researchers. This pattern reflects a hub-and-spoke configuration, where a limited number of core investigators drive much of the scientific output in the field. To further explore thematic patterns, keyword mapping using VOSviewer was conducted. Figure 3 presents the network visualisation of terms appearing in titles and abstracts of publications on AV fistula bleeding between 2005 and 2025.

Four major clusters were identified: (1) clinical complications and patient risk factors (blue), (2) diagnostic and interventional techniques (green), (3) anatomical and procedural determinants (red), and (4) outcome-oriented and methodological studies (yellow). These clusters collectively depict the multidisciplinary nature of the field and its evolution from technical management toward patient-centred care and evidence-based evaluation. Temporal analysis using overlay mapping (Fig. 4) reveals a chronological shift in research focus.

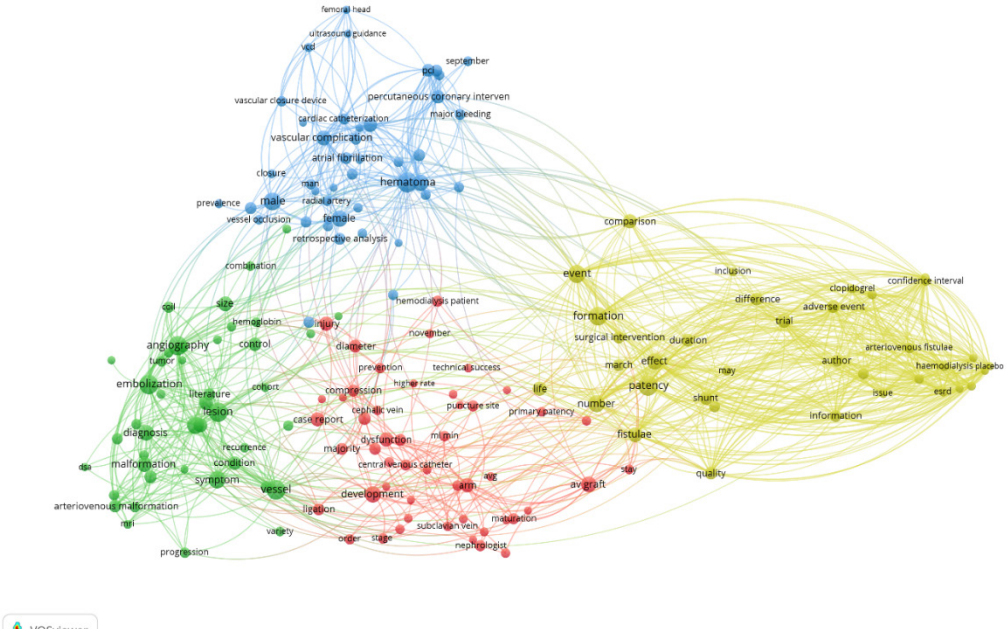

Fig. 3. Network visualization map of terms in the title/abstract fields of publications related to AV Fistula Bleeding from 2005-2025. *The VOSviewer network map reveals four main research clusters on AV fistula bleeding: blue for clinical complications and patient risk factors (e.g. haematoma, vascular complication), green for diagnostic and interventional techniques (e.g. angiography, embolisation), red for anatomical and procedural determinants (e.g. puncture site, central vein), and yellow for outcomes and methodological studies (e.g. patency, adverse events, trials). Overall, the field has progressed from technical and anatomical issues towards patient-centred outcomes and evidence-based evaluation.*

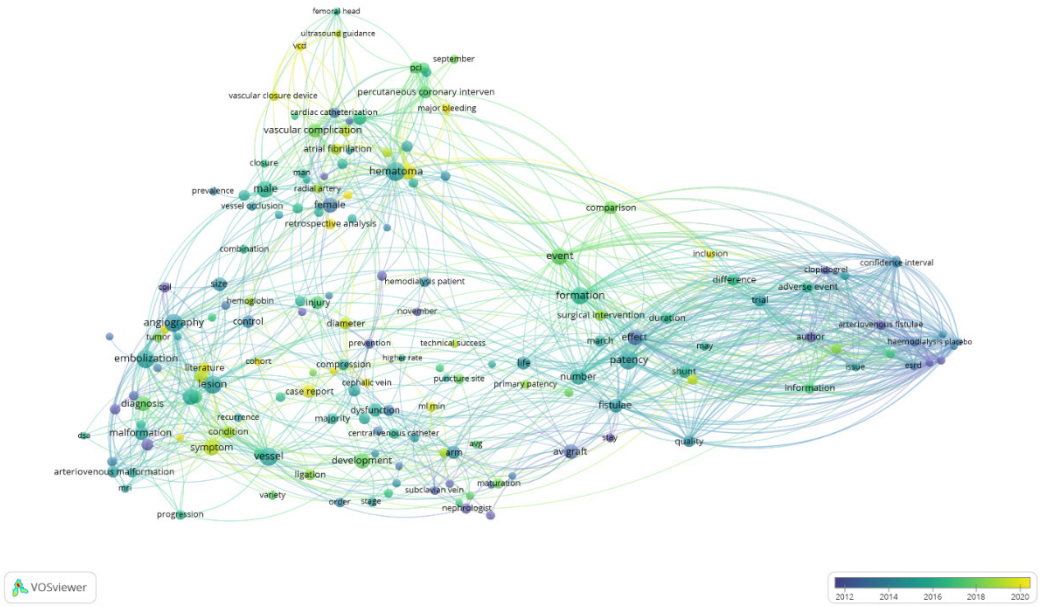

Fig. 4. Overlay visualization map of terms in the title/abstract fields of publications related to AV fistula bleeding from 2005-2025. *The VOSviewer overlay map shows a chronological shift in AV fistula bleeding research. Early studies (blue–green, 2012–2015) focused on technical and diagnostic issues such as angiography, embolisation and vascular complications, whereas more recent work (yellow, around 2018–2020) highlights patient-centred outcomes, clinical trials and methodological rigour, reflecting a move toward evidence-based evaluation and safety monitoring.*

Earlier studies, primarily from 2012 to 2015, addressed technical and diagnostic challenges such as angiography, embolisation, and vascular complications, whereas more recent publications (2018 onward) emphasise clinical trials, patient-reported outcomes, and methodological quality. Finally, the density map (Fig. 5) highlights areas of greatest research concentration.

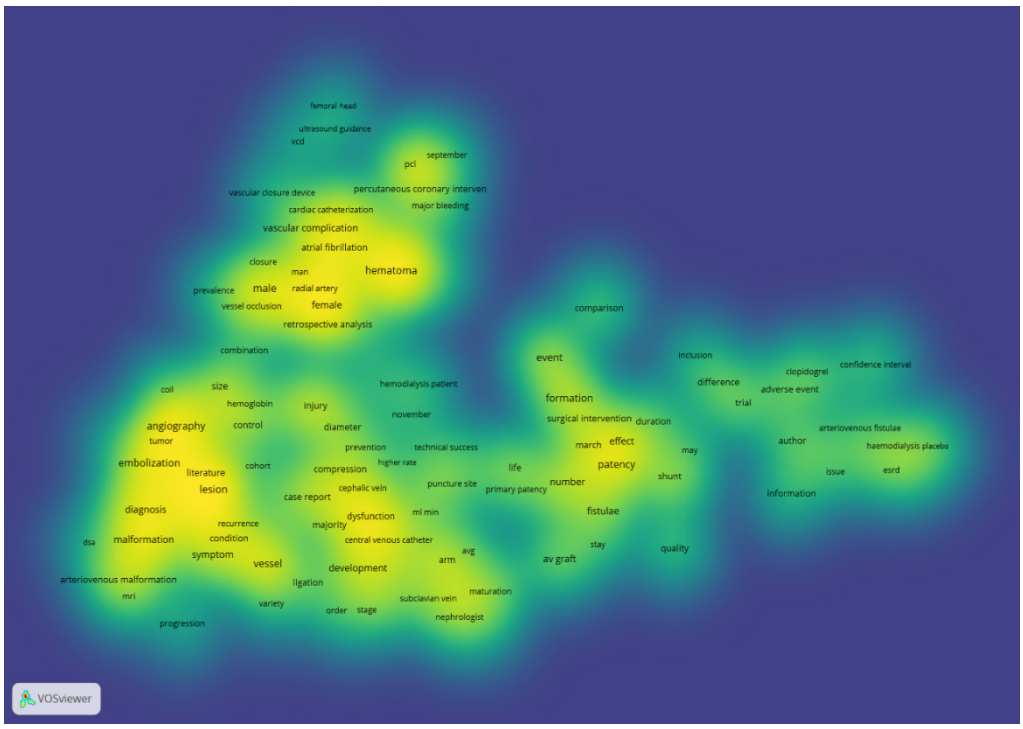

Fig. 5. Density visualization map of terms in the title/abstract fields of publications related to AV fistula bleeding from 2005-2025.

The VOSviewer density map highlights areas of highest research concentration in AV fistula bleeding. The bright yellow zones mark frequently occurring terms such as "hematoma", "vascular complication", "angiography", "embolization", "patency", and "formation", indicating these are the dominant topics in the literature. The green to blue regions show progressively lower term frequency, reflecting less-studied or emerging areas. Overall, the map reveals that research is most intense around complications and imaging/interventional techniques and also strongly focused on outcomes such as access patency and fistula formation, while more peripheral themes appear less frequently.

Discussion. The visualisation results reveal a dynamic and evolving research landscape in the management of AV fistula bleeding [3]. Four principal thematic clusters emerge. First, the blue cluster highlights patient-specific risk factors such as sex and vascular closure techniques, showing that haematoma and other vascular complications remain common adverse events after catheterisation, and that ultrasound guidance and closure devices can reduce this risk [25–29]. Second, the green cluster centres on diagnostic and interventional radiology, where angiography and endovascular embolisation have become standard for detecting and treating bleeding or vascular malformations [30, 31]. Third, the red cluster underscores anatomical and procedural determinants such as vein choice, puncture site and repeated cannulation trauma crucial to long-term patency and bleeding risk [11, 30] . Finally, the yellow cluster signals a shift towards outcome-oriented research, with growing attention to trial design, quality metrics and evidence synthesis.

Persistent hotspots particularly "haematoma" and "vascular complication" show these remain unresolved clinical challenges, while newer terms such as "confidence interval", "difference" and "inclusion" indicate rising methodological rigour and interest in well-designed clinical trials [11, 32]. Beyond bibliometric patterns, AV fistula bleeding represents a major global burden: it increases morbidity, mortality and health-care costs, and diminishes quality of life through anxiety and fear of recurrent episodes [11, 33, 34].

Effective management requires close collaboration among nephrologists, vascular surgeons, interventional radiologists and nurses [35]. Nurses play a pivotal role in early detection, patient education and home-based monitoring [36], while interventional radiology provides minimally invasive treatments such as embolisation and angioplasty for refractory haemorrhage [9]. Technological innovations, including ultrasound-guided cannulation, automated pressure sensors, and simulation-based or virtual-reality training, further support safer procedures and better risk prediction; artificial-intelligence models can also help identify high-risk patients [26–29, 37–41]

Research priorities differ by setting: high-income countries often emphasise interventional radiology and AI-based risk prediction, whereas low- and middle-income countries, including Indonesia, rely more heavily on nurse-led surveillance and patient education due to limited access to advanced technologies[10, 42–45].

Future research should prioritise large multicentre randomised trials, systematic reviews and cost-effectiveness analyses, while integrating patient-reported outcomes to capture the full clinical and psychosocial impact [1, 46–54]. Addressing these gaps will require coordinated global policies that strengthen national vascular-access registries, support nurse-led surveillance, and invest in context-appropriate technologies, in line with the World Health Organization's Global Patient Safety Action Plan and the United Nations Sustainable Development Goal 3 agenda [55–57].

Building on the above findings, recent bibliometric investigations show that although research output from LMICs is growing, authors affiliated solely with LMIC institutions are underrepresented in senior authorship positions—especially in multicountry studies and high-impact journals [58,59]. This finding aligns with patterns seen in global emergency medicine and broader global health literature, where leadership tends to cluster in high-income countries even when studies are conducted in LMICs [60, 61]. Therefore, our co-authorship results suggest there is room to improve equity of research leadership by enabling more LMIC-based researchers to take leading roles through funding, capacity building and deliberate partnership structures [58–61].

This study is subject to several limitations. First, restricting the search to English-language publications indexed in Scopus and PubMed may have excluded relevant studies published in other languages or non-indexed sources. Second, citation counts inherently favour older publications, which have had more time to accumulate citations, and tend to privilege research output from high-income countries where visibility and academic networks are stronger. These factors may bias the apparent influence of particular authors, countries or institutions and should be considered when interpreting the bibliometric indicators.

Future research should build on these findings through well-designed multicentre clinical trials and the development of national or international vascular-access registries. Such initiatives would allow robust evaluation of prevention and management strategies for AV fistula bleeding across different populations and healthcare settings. In addition, AI-based risk prediction models and other machine-learning approaches could be explored to identify high-risk patients and to guide personalised interventions. These steps would provide a more comprehensive evidence base and increase the practical relevance of future work.

Conclusions. This bibliometric study provides a comprehensive overview of research trends in AV fistula bleeding over the last two decades, identifying four main thematic clusters: clinical complications, diagnostic and interventional strategies, anatomical considerations, and outcome-based evaluations, showing a gradual evolution from technical management toward more patient-centred, evidence-based approaches. The density and overlay visualisations highlight a chronological shift, with recent studies focusing on pharmacological safety, adverse-event monitoring, and long-term fistula patency. Moving forward, research should prioritise standardised bleeding-management protocols, stronger roles for nursing and multidisciplinary teams, integration of patient-reported outcomes, and predictive analytics using machine learning, alongside studies on educational interventions, simulation-based training, and quality-of-life impacts. These directions underscore the need for integrated, evidence-based strategies in which clinicians emphasise early detection and standardised management while researchers explore innovative models and under-addressed topics. Greater involvement of multidisciplinary teams, including nursing, together with investment in patient education and outcome tracking, will strengthen both prevention and intervention strategies and support the development of holistic, preventive, and personalised approaches to vascular access care in haemodialysis.

Conflict of interest. The authors declare no conflict of interest in this study.

Acknowledgement. The authors gratefully acknowledge the support of the Doctoral Programme in Nursing, Faculty of Health Sciences, Jenderal Soedirman University, throughout this study.

Funding. The authors received no financial support from any organization for this study.

Authors' contributions.

Novita Anggraeni: conceived the study, designed the methodology, and drafted the initial manuscript;

Saryono: contributed to data collection, data analysis, and critical revision of the manuscript. Both authors read and approved the final version of the manuscript.

Data availability. The corresponding author will provide interested parties with access to the dataset upon reasonable request.

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