ORIGINAL ARTICLE

UNCOVERING HEMODYNAMIC INNOVATION: AN INTEGRATED BIBLIOMETRIC ANALYSIS OF THE USE OF DOPPLER TECHNOLOGY IN THE DIAGNOSIS AND MANAGEMENT OF OBSTRUCTIVE SLEEP APNEA

Arman Yurisaldi Saleh1, Dwi Arwandi Yogi Saputra2, Riezky Valentina3, Tirta Darmawan Susanto 4
1Neurology Department Faculty of Medicine UPN Veteran Jakarta, Indonesia
2Department of Public Health Sciences, Faculty of Medicine, UPN Veteran Jakarta, Indonesia
3Neurology Department Faculty of Medicine UPN Veteran Jakarta, Indonesia
4Family Medicine and Primary Care Department, Universitas Pelita Harapan, Indonesia

ABSTRACT

1) Introduction: Obstructive Sleep Apnea (OSA) is a sleep disorder causing hypertension, cardiovascular disease, and metabolic disorders. Doppler technology, a non-invasive imaging method, is used to detect vascular changes in OSA patients. A bibliometric review of literature on Doppler use in OSA cases can help identify trends and areas for further study. This analysis can reveal leading journals, influential authors, and the relationship between diagnostic technology and clinical knowledge. It can also help in setting research priorities and developing innovative solutions for OSA diagnosis and management.; 2) Materials and methods: This research aims to explore the evolution of scientific disciplines by finding and identifying trends, patterns and correlations in scientific texts related to certain topics. The focus of this study was doppler and osa or osbstructive sleep apneu using both quantitative and qualitative analysis. 3) Results and discussion:. Bibliometric analysis reveals increasing publications, global collaboration, significant diagnostic standards are not yet evenly distributed; Doppler technology effectively detects hemodynamic dynamics in OSA. and 4) Conclusions: The review emphasizes the importance of Doppler technology in improving OSA diagnostics and treatments. It highlights the need for collaboration between academic, clinical, and technological domains to improve care standards. The study highlights the transformative potential of hemodynamic understanding and Doppler technology in sleep medicine. This research was conducted in April 2025

Keywords: Obstructive Sleep Apnea (OSA), Doppler Ultrasound, Hemodynamics, Bibliometrics, Diagnostics, Management, Sleep Medicine

ABSTRAK

1) Pendahuluan: Obstructive Sleep Apnea (OSA) adalah gangguan tidur yang menyebabkan hipertensi, penyakit kardiovaskular, dan gangguan metabolik. Teknologi Doppler, metode pencitraan non-invasif, digunakan untuk mendeteksi perubahan vaskular pada pasien OSA. Ulasan bibliometrik literatur tentang penggunaan Doppler pada kasus OSA dapat membantu mengidentifikasi tren dan area yang memerlukan penelitian lebih lanjut. Analisis ini dapat mengungkap jurnal terkemuka, penulis berpengaruh, dan hubungan antara teknologi diagnostik dan pengetahuan klinis. Hal ini juga dapat membantu dalam menetapkan prioritas penelitian dan mengembangkan solusi inovatif untuk diagnosis dan pengelolaan OSA.; 2) Bahan dan metode: Penelitian ini bertujuan untuk mengeksplorasi evolusi disiplin ilmu dengan menemukan dan mengidentifikasi tren, pola, dan korelasi dalam teks ilmiah yang terkait dengan topik tertentu. Fokus studi ini adalah Doppler dan OSA atau apnea tidur obstruktif, menggunakan analisis kuantitatif dan kualitatif.
3) Hasil dan pembahasan: Analisis bibliometrik menunjukkan peningkatan publikasi, kolaborasi global, dan standar diagnostik yang signifikan belum terdistribusi secara merata; teknologi Doppler secara efektif mendeteksi dinamika hemodinamik pada OSA. dan 4) Kesimpulan: Tinjauan ini menekankan pentingnya teknologi Doppler dalam meningkatkan diagnostik dan pengobatan OSA. Tinjauan ini menyoroti kebutuhan akan kolaborasi antara bidang akademik, klinis, dan teknologi untuk meningkatkan standar perawatan. Studi ini menyoroti potensi transformatif pemahaman hemodinamik dan teknologi Doppler dalam kedokteran tidur. Penelitian ini dilakukan pada April 2025

Kata kunci: Obstructive Sleep Apnea (OSA), Ultrasonografi Doppler, Hemodinamik, Bibliometrik, Diagnostik, Pengelolaan, Kedokteran Tidur

Correspondence :

Arman Yurisaldi Saleh
Neurology Department Faculty of Medicine UPN Veteran Jakarta, Indonesia
Email : drarmanyurisaldic@gmail.com

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Introduction

Obstructive Sleep Apnea (OSA) is a complex sleep disorder characterized by recurrent episodes of airway obstruction during sleep. This condition contributes to the risk of hypertension, cardiovascular disease, and serious metabolic disorders. Research into the mechanisms and hemodynamic impacts of OSA is crucial for the development of more effective diagnostic and treatment strategies(1).

Doppler technology, as a non-invasive imaging method, has been widely applied to measure blood flow and detect vascular changes. In the context of OSA, the use of Doppler allows for real-time identification of hemodynamic changes, which is critical for understanding the cardiovascular response to apnea episodes(1, 2).

Although there have been many studies evaluating the clinical application of Doppler in OSA patients, there has been no bibliometric review that systematically maps the patterns, trends, and impact of related literature in Scopus-indexed journals. This gap opens up an opportunity to explore the dynamics of publications and scientific collaborations in this field(3).

Bibliometric methods allow quantitative analysis of publication data, including citation analysis, h-index, and collaboration networks between researchers. This approach provides a historical overview and trends in research development, thus helping to identify areas that are still under-explored or require further study(3).

The advantage of bibliometric studies lies in their ability to integrate research data from various sources and create a comprehensive scientific map. Thus, research on the use of Doppler in OSA can reveal leading journals, influential authors, and the relationship between improvements in diagnostic technology and advances in clinical knowledge.(3, 4).

The use of Doppler in OSA evaluation not only offers the potential for early detection of hemodynamic changes, but also supports monitoring the effectiveness of therapeutic interventions. With bibliometric analysis, researchers can measure the increasing trend of clinical applications that ultimately pave the way for innovation in OSA management.(4).

In addition, bibliometric studies can reveal patterns of international and interdisciplinary collaborations that occur between institutions. By evaluating these collaborative networks, research can show how cross-border knowledge exchange and cooperation have significantly contributed to the development of Doppler technology for OSA.(4).

A review of publication trends in this field provides insight into the paradigm shift from traditional diagnostic methods to advanced technological approaches. This information is useful in setting research priorities and strategically allocating resources to improve the quality of OSA diagnosis and therapy(5).

Bibliometric analysis also opens up the possibility to identify research trends that lead to the development of new technologies and improved clinical management. By mapping the research journey over several decades, this study is able to reveal key moments and innovations that were turning points in the application of Doppler for OSA evaluation(5).

Overall, the bibliometric study of Doppler use in OSA cases offers important contributions to the scientific and clinical communities. The results of this study are expected to not only strengthen the scientific foundation regarding the pathophysiological

mechanisms of OSA, but also provide strategic guidance for the development of innovative solutions in the diagnosis and management of OSA in the future(1-5).

Materials and methods

Methods

Bibliometric research is a methodological approach that employs scientific publishing data to delineate and examine the evolution of a scientific discipline. This research seeks to find and delineate trends, patterns, and correlations within scientific texts pertaining to specific subjects. This research focuses on the subject of doppler and osa or osbstructive sleep apneu. This study utilizes data from www.scopus.com, a prominent and reputable database for scientific articles. This research was conducted in early April 2025.

To carry out bibliometric research, the steps to follow are as follows:

1. Determine search keywords. In this research, the keywords used are focused Cognitive enhancer. These keywords are entered into the search column on the www.scopus.com site by selecting the topic field (title, abstract, keywords).
2. Filter search results. In this study, Were not filtered.
3. Retrieve the data from the search results. This study involves the retrieval of search result data in three distinct formats, namely:
    - CSV (comma-separated value), which contains basic information about the document, such as title, author, affiliation, year, source, abstract, and keywords.
    - RIS (research information system), which contains detailed information about a document, including the references cited by the document.

Data Collection

A search was conducted on the Scopus website using the specified terms, with the understanding that this platform encompasses research that is deemed to possess validity: TITLE – ABS – KEY (doppler) AND TITLE – ABS – KEY (osa) OR TITLE – ABS – KEY (osbstructive sleep apneu) are the titles of the products that are under consideration. Three hundred and sixty eight documents were received by us. We then save the document from Scopus in the form of a file with the extension.csv following this step.

Data Analysis

Both the Biblioshiny and Vosviewer software packages were utilised in the analysis process.

Quantitative Analysis

Documents by Year

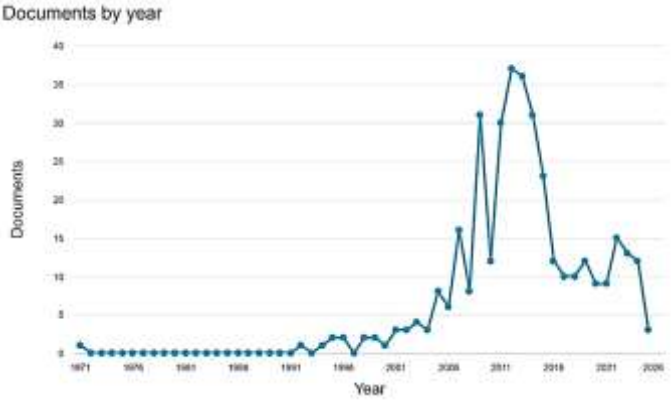

Figure 1. Documents by year

Figure 1 indicates a rise in the number of documents, highest in 37 documents by 2012. The earliest document dates back to 1971 and entitled Laser Doppler- velocity measurements in cold gases and flames written by James H(6) and the latest document in 2025 entitled Predictors of corporo-venocclusive dysfunction in

men with bilateral nerve-sparing radical prostatectomy written by Flores, J.M et al., Assessment of microcirculation among patients with obstructive sleep apnea after CPAP treatment written by Brożyna-Tkaczyk, K. , Myśliński, W. , Dybała, A. , Paprzycki, P., A Novel Treatment of Obstructive Sleep Apnea Using Continuous Wave Interferometry Radar written by Xu, G et al.,(7-9)

Most Relevant Sources

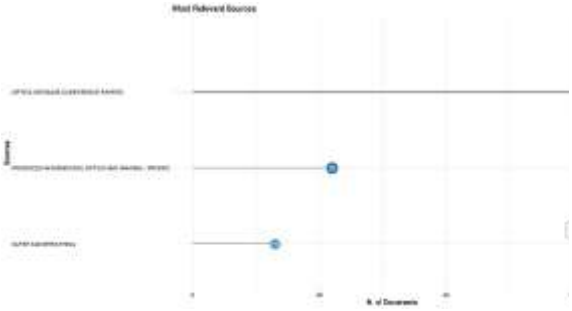

Figure 2. Most Relevant Sources

According to Figure 2. Most relevant source is Optics InfoBase Conference Papers with 63 documents. Optics InfoBase Conference Papers is a publication by Optica Publishing Group that features research in various fields, including computer networks and communications, computer science applications, electronic and optical materials, health informatics, information systems, and material mechanics. The journal is indexed in Scopus, although the exact year of inclusion is unclear. As of the latest update, its SCImago Journal Rank (SJR) score is 0.108, indicating its academic influence and impact in the research community.

Next is Journal Progress in Biomedical Optics and Imaging - Proceedings of SPIE with 22 documents. Progress in Biomedical Optics and Imaging - Proceedings of SPIE is a journal focused on research in biomedical optics and medical imaging. It has been indexed in Scopus since 2004, making it a recognized source of scientific literature in this field. As of the latest update, its SCImago Journal Rank (SJR) score is 0.226, reflecting its academic influence. The journal is published by SPIE (The International Society for Optics and Photonics) and accepts research manuscripts on various topics, including atomic and molecular physics, optics, biomaterials, electronic and optical materials, and radiology, nuclear medicine, and medical imaging.

Next is Journal Sleep and Breathing with 12 documents. Sleep and Breathing is a journal dedicated to the study and clinical practice of sleep medicine. It has been indexed in Scopus since 1996, with coverage extending through 1997 and from 1999 to the present. The journal is published by Springer Verlag, a reputable academic publisher. As of the latest update, its SCImago Journal Rank (SJR) score is 0.753, reflecting its impact in the field. The journal accepts manuscripts on various topics, including clinical neurology, otorhinolaryngology, sleep disorders and breathing-related conditions, the physiology and pathophysiology of sleep, and the diagnosis and treatment of sleep disorders.

Factorial map of the most cited documents

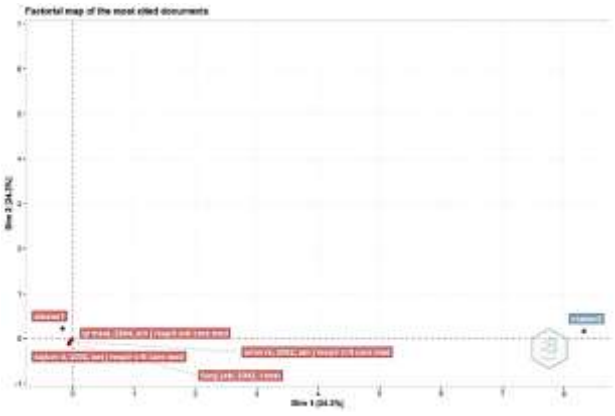

Figure 3. Factorial map of the most cited documents

According to Figure 3, The most cited document based author keyword is Continuous positive airway pressure treatment improves pulmonary hemodynamics in patients with obstructive sleep apnea. The research paper Continuous Positive Airway Pressure Treatment Improves Pulmonary Hemodynamics in Patients with Obstructive Sleep Apnea was authored by Dimitar Sajkov, Tingting Wang, Nicholas A. Saunders, Alexandra J. Bune, and R. Douglas McEvoy. It was published in the American Journal of Respiratory and Critical Care Medicine in 2002, appearing in Volume 165, Issue 2(10).

This study examines the effects of Continuous Positive Airway Pressure (CPAP) therapy on pulmonary hemodynamics in individuals with Obstructive Sleep Apnea (OSA). The researchers aimed to determine whether CPAP treatment could reduce pulmonary hypertension and improve vascular function in OSA patients. Key findings of the study indicate that pulmonary artery pressure (Ppa) significantly decreased after four months of CPAP treatment, leading to improved pulmonary vascular resistance and better blood flow. The greatest improvements were observed in patients with preexisting pulmonary hypertension, suggesting that CPAP therapy may have cardioprotective benefits. Additionally, the study found that CPAP helped lower systemic diastolic blood pressure, indicating its potential in managing broader cardiovascular complications associated with OSA(10).

Overall, this research highlights the positive effects of CPAP therapy on pulmonary circulation, reinforcing its role in treating cardiovascular issues linked to obstructive sleep apnea(10).

Factorial Map Of The Documents With The Highest Contributes

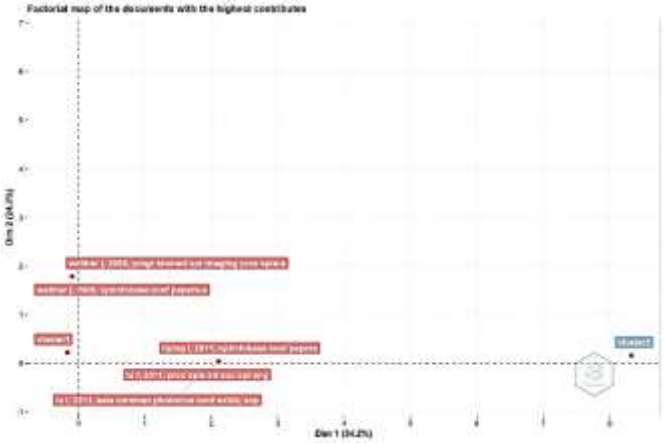

Figure 4. Factorial map of the documents with the highest contributes

In Figure 4, The most contributed manuscript based on author keyword Study on the orientation of pigment in thylakoid based on polarization technique. The research paper "Study on the Orientation of Pigment in Thylakoid Based on Polarization Technique" was authored by Liping L., Caiqin H., Xiaowu N., and Xiaosen L.. It was published in the SPIE Digital Library Proceedings in 2011 as part of the Asia Communications and Photonics Conference (ACP 2011)(11).

This study investigates the orientation of pigments in thylakoid membranes using polarization spectroscopy. The researchers analyzed the absorption and fluorescence spectra of thylakoid samples from Brassica chinensis, a type of Chinese cabbage. Their findings suggest that polarization techniques can effectively reveal the arrangement of pigments, improving our understanding of photosynthetic efficiency and light-harvesting mechanisms in plants. The study's insights contribute to biophotonics and plant physiology, offering valuable implications for research on energy transfer within photosynthetic system(11).

Documents by Author

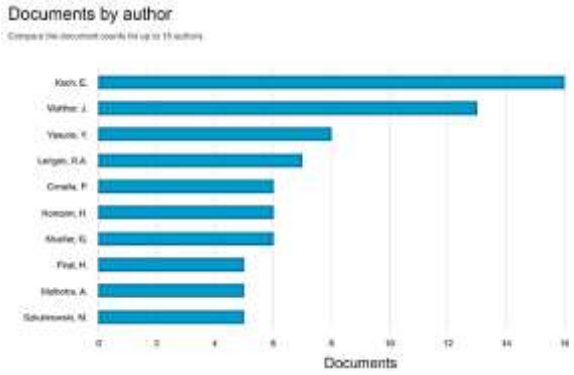

Figure 5. Documents by Author

According to Figure 5. Here are the 3 authors with the most documents. The first author is named Koch, E. with 16 documents(12-27). Here are some articles written by Koch, E entitled : Magnetomotive imaging of iron oxide nanoparticles as cellular contrast agents for optical coherence tomography., An advanced algorithm for dispersion encoded full range frequency domain optical coherence tomography., Vibration of the human tympanic membrane measured with OCT in a range between 0.4 kHz and 6.4 kHz on an ex vivo sample., Magnetomotive imaging of iron oxide nanoparticles as cellular contrast agents for optical coherence tomography., An advanced algorithm for dispersion encoded full range frequency domain optical coherence tomography.

The next author is Walther, J., with 13 documents(12, 13, 16-26). Here are some articles written by Walther, J., entitled : Magnetomotive imaging of iron oxide nanoparticles as cellular contrast agents for optical coherence tomography., Enhanced joint spectral and time domain optical coherence tomography for quantitative flow velocity measurement., Blood flow measurement in the in vivo mouse model by the combination of Doppler OCT and the signal power decrease in spectral domain OCT., Resonant Doppler imaging with common path OCT., Optical angiography from optical coherence tomograhy using a computational phase-shift.

The next author is named Yasuno, Y., with 8 documents(28-35). Here are some articles written by Yasuno, Y., entitled : Three-dimensional polarization and doppler imaging of living tissue by multi-contrast optical coherence tomography., Passive component based multi-functional jones matrix optical coherence tomography for doppler and polarization sensitive imaging of retina., In Vivo and three-dimensional imaging of vasculature in the eye by optical coherence tomography., High-speed and high-sensitive optical coherence angiography., Optical coherence angiography for the retina and choroid.

Documents by Subject Area

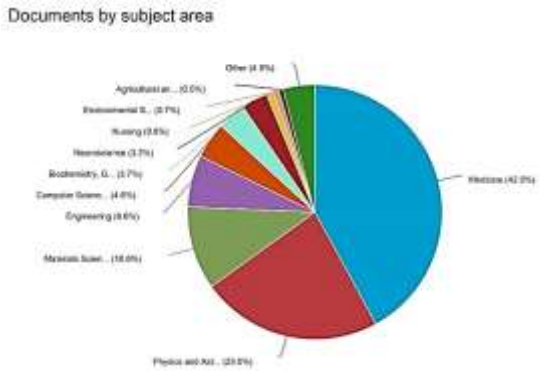

Figure 6. Documents by Subject Area

According to Figure 6, Based on the pie chart titled Documents by Subject Area, The image is a pie chart illustrating the distribution of 368 documents across various subject areas. The largest portion, 42.0%, is dedicated to Medicine, indicating a strong focus on medical research. Physics and Astronomy account for 23.0%, showing significant contributions from the physical sciences. Materials Science follows with 10.6%, reflecting research interest in material properties and innovations.

Other fields such as Engineering (6.6%), Computer Science (4.6%), and Biochemistry, Genetics, and Molecular

Biology (3.7%) demonstrate a balanced representation of technological and biological sciences. Meanwhile, Neuroscience (3.3%) explores brain and nerve-related studies, while Nursing (0.9%), Environmental Science (0.7%), and Agricultural and Biological Sciences (0.5%) contribute to specialized fields. The remaining 4.0% falls into the Other category, encompassing disciplines outside the major listed subjects.

This distribution suggests a dominant interest in Medicine and Physics while maintaining interdisciplinary diversity.

Documents by affiliation

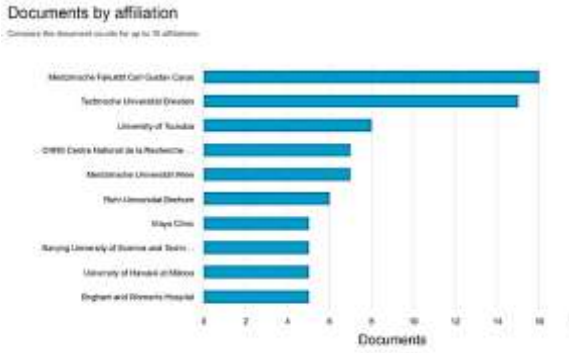

Figure 7. Documents by affiliation

According to Figure 7, in first place, the producer of the most documents is affiliated with Medizinische Fakultät Carl Gustav Carus with 16 documents; next is affiliated Technische Universität Dresden with 15 documents. And the next is University of Tsukuba with other 8 documents. And the next is CNRS Centre National de la Recherche Scientifique and Medizinische Universität Wien with each other 7 documents.

Documents by country or territory

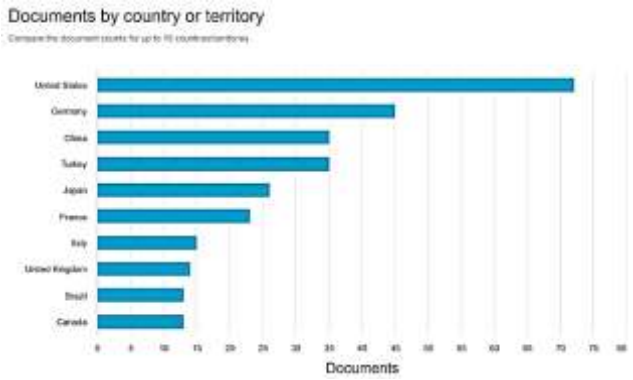

Figure 8. Documents by country or territory

According to Figure 8, countries with the largest contribution is United States with 72 documents. This is significantly higher compared to other countries, with Germany with 45 documents, China and Turkey with 35 documents, Japan with 26 documents and France at 23 documents.

Network Visualization

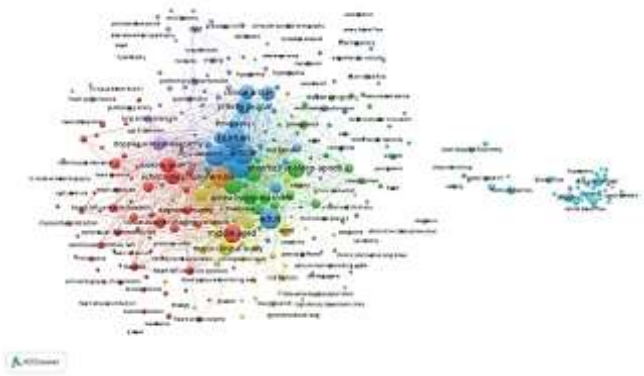

Figure 9. Network Visualization

Figure 9 indicates that the examined areas remain unassociated with other regions delineated by edges. that part is: postoperative period, adenotonsillar hypertrophy, tonsil, hypertrophy, tonsillectomy, preschool child, adolescent, computer-assisted tomography, oxidative stress, reference value, metabolism, hypercapnia, lung pressure, chi-square distribution, heart performance, pulmonary artery, heart left ventricle, heart muscle relaxation, m mode echocardiography, right ventricle,

myocardial contraction, ventricle, mitral valve, echocardiography, three-dimensional, stroke volume, heart atrium conduction, diastolic function, p wave, blood pressure monitoring, ambulatory, etiology, glucose, triacylglycerol, cholesterol blood level, high-density lipoprotein cholesterol, beta adrenergic receptor blocking agent, calcium channel blocking agent, diuretic agent, chronic obstructive lung disease, spirometry, obstructive sleep apnea (OSA), sleep time, sleep research, sleep monitoring, diagnosis, multivariate analysis, arterial wall thickness, arterial stiffness, young adult, heart, cerebrovascular circulation, blood vessel reactivity, vascular resistance, brain blood flow, endothelial vascular, brachial artery, artery blood flow, vasodilation, case report, hemodynamics, blood flow, doppler effect, doppler, in-vivo, spectrometers, retinal blood flow, flowmeters, laser doppler flowmetry, and velocity..

Overlay Visualization of Scopus, Database Using Vosviewer

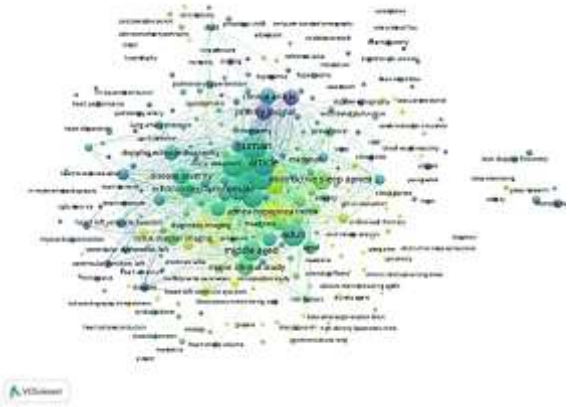

Figure 10. Overlay visualization of scopus, database using Vosviewer

According to Figure 10. In the overlay visualization, it appears that the keywords that are being researched a lot approaching 2018 are the parts colored yellow, namely : apnea hypopnea index, diagnostic imaging, hemodynamic parameters, retrospective study, blood pressure monitoring, creatinine, etiology, diuretic agent, beta adrenergic reseptor block, triacylglycerol, high density lipoprotein chloe, sleep time, diagnosis, obstructive sleep apnea (osa), spirometry, chronic obstructive lung disea, sleep monitoring, sleep research, clinical evaluation.

.

Density Visualization

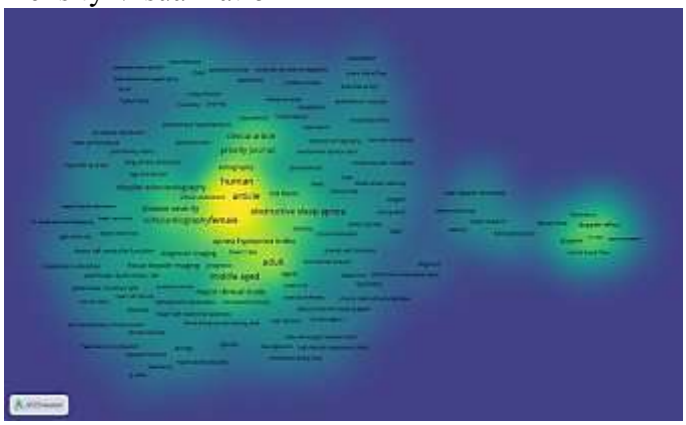

Figure 11. Density visualization

As illustrated in Figure 11. In the visual circulation density, it appears that the part that is already saturated with research is yellow, while the part that is not yet saturated is slightly yellow and dominantly green, namely keywords : postoperative period, adenotonsillar hypertrophy, tonsil, hypertrophy, pulmonary hypertension, chi-square distribution, heart performance, pulmonary artery, heart left ventricle, doppler echocardiography, heart muscle relaxation, m mode echocardiography, heart ventricle, right ventricle, heart ventricles, heart left ventricle function, diagnostic imaging, tissue doppler imaging, ventricular dysfunction, left, ventricular function, left, mitral valve, diastole, myocardial contraction, heart left ventricle ejection, echocardiography, three-dimens, stroke volume, heart atrium conduction, diastolic function, heart atria, p wave, child, preschool child, computer assisted tomography, adolescent, oxidative stress, lung pressure, morbidity, snoring, hypoxemia, hypercapnia, prevalence, sleep, clinical

trial, sleep apnea, clinical evaluation, arterial wall thickness, multivariate analysis, prognosis, predictive value, hemodynamic parameters, blood pressure monitoring, amb, etiology, glucose, triacylglycerol, heart stroke volume, risk factors, beta adrenergic receptor block, high density lipoprotein chole, cholesterol blood level, vasodilation, artery blood flow, brachial artery, reference value, metabolism, endothel, vascular, brain blood flow, doppler echography, vascular resistance, endothelial dysfunction, cerebrovascular circulation, cpap, blood vessel reactivity, oxygen, young adult, sleep monitoring, sleep research, velocity, hemodynamics, laser doppler flowmetry, blood flow, flowmeters, and tonsillectomy.

Thematic Map

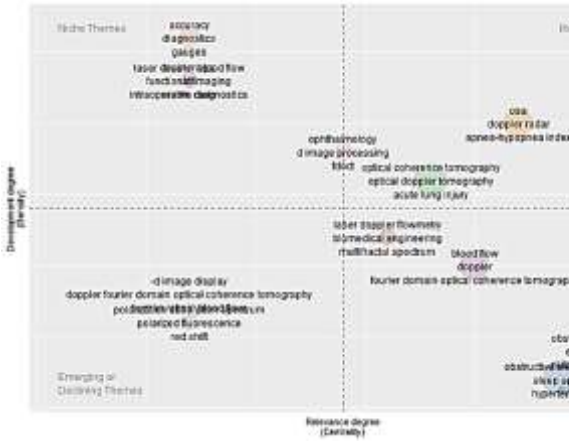

Figure 12. Thematic map

According to Figure 12, On the thematic map based on author keyword, the following is an explanation for each keyword in each quadrant in the thematic map resulting from bibliometric. Here is an explanation of the meaning of each quadrant in the thematic map and examples of document titles relevant to keywords in each quadrant.

The keywords identified in the image can be classified into four distinct themes based on their relevance and impact in the field. Niche Themes encompass specialized concepts with specific applications, such as accuracy diagnostics, gauges, laser Doppler blood flow measurement, functional imaging, and intraoperative diagnostics. These terms focus on precise methods, instruments, and imaging techniques that play a critical role in medical diagnostics but may not have broad application outside their specialized domains. Example documents related to these topics include "Advancements in Accuracy Diagnostics for Early Disease Detection" and "Utilization of Gauges in Medical Diagnostics."

Motor Themes, on the other hand, represent core elements that drive research and technological progress. Keywords such as obstructive sleep apnea (OSA), Doppler radar, and the Apnea-Hypopnea Index are pivotal in understanding sleep disorders and improving diagnostic techniques. Research in these areas informs clinical practices, making them essential components of medical innovation. Example document titles include "Management of Obstructive Sleep Apnea in Adults" and "Applications of Doppler Radar in Medical Imaging."

Meanwhile, Emerging or Declining Themes encompass keywords related to trends that are either gaining traction or fading within medical research. These include three-dimensional image displays, Doppler Fourier domain optical coherence tomography, human research, polarized fluorescence, and red shift. Some of these topics signal advancements in imaging technology, while others reflect fundamental shifts in biomedical studies. Documents such as "Advances in 3D Image Display for Medical Applications" and "Doppler Fourier Domain Optical Coherence Tomography in Ophthalmology" provide insights into these evolving themes.

Finally, Basic Themes refer to foundational concepts in medical

research that serve as the backbone for further exploration. These include obstructive sleep apnea, echocardiography, general sleep apnea, hypertension, and the intersection of obstructive sleep apnea with hypertension. These subjects are widely studied and have well-established significance in medical practice and patient care. Example documents include "Obstructive Sleep Apnea: Diagnosis and Treatment" and "The Link Between Obstructive Sleep Apnea and Hypertension..

Thematic Evolution

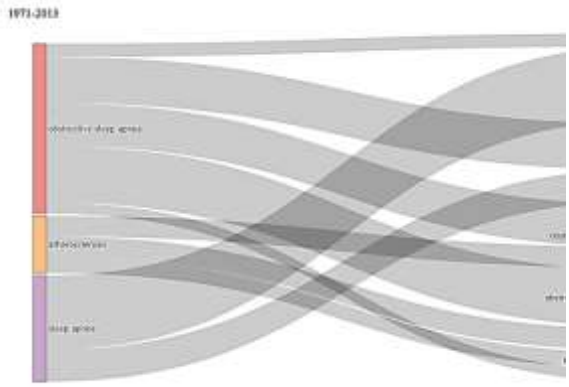

Figure 13. Thematic Evolution

According to Figure 13, There was an evolution of changes in themes in research in 1971–2013 with the keywords is obstructive sleep apnea, atherosclerosis, sleep apnea. The theme then changed in 2014–2025 to sleep apnea, echocardiography, obstructive sleep apnea, obstructive sleep apnoea, osa, heart rate variability and hypertension.

Topic Dendogram

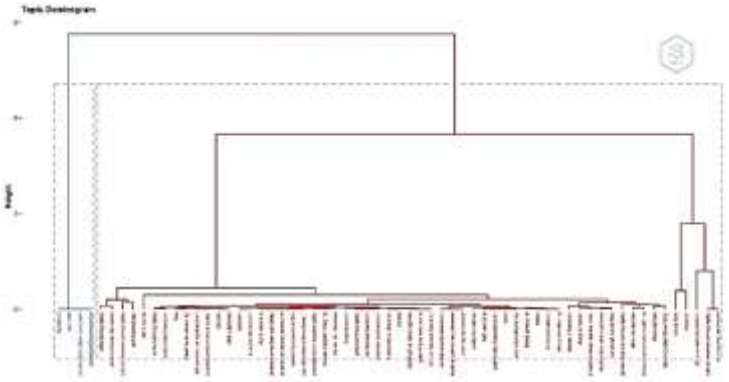

Figure 14. Dendogram

According to Figure 14. There are 2 large clusters According to keywords. There are 2 clusters of blue and red.

Qualitative Analysis

Tabel 1. Qualitative analysis of doppler in obstructive sleep apnea

No.	Doppler is used to evaluate what in the following studies	What doppler specifications were used in the following study?	Reference no
1.	Doppler assesses corporo-venocclusive dysfunction (CVOD) using penile Duplex Doppler Ultrasound	End-diastolic velocity (EDV) ≥ 5 cm/s bilaterally defines CVOD diagnosis.	(8)
2.	Doppler assesses microcirculation changes after CPAP treatment in OSA patients.	Laser Doppler Flowmetry (LDF) measured endothelial function before and after therapy.	(7)
3.	Doppler detects obstructive sleep apnea (OSA) using continuous wave radar technology.	Continuous wave (CW) Doppler radar monitored vital signs for OSA detection.	(9)
4.	Doppler assesses right ventricular function improvements after CPAP therapy for OSA.	Echocardiographic Doppler followed American Society for Echocardiography guidelines precisely.	(36)
5.	Doppler assesses cardiac function and atrial arrhythmias in hypertensive OSA patients	Cardiac Doppler ultrasound followed polysomnography and electrocardiography for precise evaluation	(37)
6.	Doppler assesses heart rate variability (HRV) in children with SCD.	Acoustic pharyngometry and polysomnography evaluated compliance and HRV modifications precisely	(38)
7.	Doppler assesses left atrial and ventricular function in OSA patients.	Transthoracic echocardiography evaluated LA and LV remodelling comprehensively	(39)
8.	Doppler assesses	Cardiac Doppler	(40)

	cardiovascular impact of non-invasive ventilation in overlap syndrome	ultrasound measured heart function changes before and after NIV	
9.	Doppler assesses pulmonary hypertension and cardiac function in COPD-OSA patients.	Echocardiography measured pulmonary artery pressure and heart function precisely	(41)
10.	Doppler assesses cardiovascular impacts of OSA in hypertensive individuals comprehensively	Cardiac Doppler ultrasound examined interventricular septum thickness and LVEDV precisely	(42)
11.	Doppler assesses heart rate variability patterns in obstructive sleep apnea patients.	24-hour Holter monitoring measured HRV using time- and frequency-domain indices.	(43)
12.	Doppler assesses vascular aging and endothelial dysfunction in OSA patients.	Carotid-femoral pulse wave velocity measured vascular aging and endothelial senescence	(44)
13.	Doppler assesses pulmonary hypertension and cardiac function in pediatric OSA patients.	Echocardiography measured pulmonary artery pressure changes after adenoidectomy and	(45)
14.	Doppler assesses pancreatic fat infiltration in obstructive sleep apnea patients.	Modified abdominal ultrasound evaluated non-alcoholic fatty pancreatic disease precisely	(46)
15.	Doppler assesses cardiac arrhythmias and autonomic dysfunction in OSA patients.	Echocardiography measured cardiac structural remodeling and arrhythmia development precisely.	(47)
16.	Doppler assesses sleep apnea severity using radar-based monitoring technology effectively	Continuous-wave Doppler radar analyzed apnea and hypopnea events precisely.	(48)
17.	Doppler assesses cardiac function in heart failure patients with sleep apnea.	Echocardiography measured left ventricular ejection fraction and systolic-diastolic impairment.	(49)
18.	Doppler assesses hypertension-mediated organ damage in patients with obstructive sleep apnea.	Echocardiography measured left ventricular hypertrophy and arterial stiffness precisely.	(50)
19.	Doppler assesses cerebral blood flow and substantia nigra hyperechogenicity in OSA.	Transcranial sonography measured bilateral cerebral blood flow variations precisely.	(51)
20.	Doppler assesses venous insufficiency and sleep quality in diabetic patients.	Doppler ultrasonography evaluated vascular conditions during initial clinical examination precisely	(52)
21.	Doppler assesses cardiac autonomic modulation in COPD and obstructive sleep apnea patients.	Heart rate variability and R-R intervals measured autonomic dysfunction precisely.	(53)
22.	Doppler assesses heart remodeling and diastolic dysfunction in OSA patients.	Transthoracic echocardiography measured atrial diameter and diastolic dysfunction precisely.	(54)
23.	Doppler assesses vascular changes and glymphatic system impairment in OSA patients.	Dynamic contrast-enhanced MRI evaluated glymphatic drainage system fluid dynamics precisely.	(55)
24.	Doppler assesses tricuspid regurgitation velocity and cerebral blood flow in SCD.	Transcranial duplex and echocardiography measured vascular flow and cardiac function precisely	(56)
25.	Doppler assesses cardiac function changes in brachycephalic dogs with BOAS.	Echocardiography measured left atrium size and right ventricular function precisely	(57)
26.	Doppler assesses pulmonary artery wedge pressure and diastolic dysfunction in OSA	Tissue Doppler echocardiography measured PAWP using noninvasive assessment techniques precisely.	(58)
27.	Doppler assesses cardiac autonomic control and functional impairment in COPD-OSA patients	Echocardiography and polysomnography assessed heart variability and autonomic nervous dysfunction precisely.	(59)
28.	Doppler assesses ventricular remodeling and cardiac dysfunction in OSA patients.	Transthoracic echocardiography measured myocardial performance index and ventricular function precisely.	(60)
29.	Doppler assesses pulmonary artery systolic pressure in children with OSA.	Doppler echocardiography measured PASP before and after adenotonsillectomy precisely	(61)
30.	Doppler is used to evaluate pulmonary artery systolic pressure in children	Doppler echocardiography was performed at baseline and follow-up examinations.	(62)
31.	Doppler is used to evaluate vasodilative endothelial function in OSA patients.	Laser Doppler Flowmetry was used to assess endothelial function changes.	(63)
32.	Doppler is used to evaluate right ventricular longitudinal strain in OSA	Echocardiographic Doppler assessed RV free-wall and global longitudinal strain.	(64)
33.	Doppler is used to evaluate carotid intima-media thickness in OSA.	High-throughput Multiplex Immunobead Assay measured	(65)

		vascular endothelial dysfunction biomarkers.	
34.	Doppler is used to evaluate coronary artery flow velocity reserve.	Doppler system measured CFVR at multiple experimental time points.	(66)
35.	Doppler is used to evaluate atrial electromechanical delay and strain.	Transthoracic echocardiography measured AEMD and apical 4-chamber longitudinal strain.	(67)
36.	Doppler is used to evaluate brachial artery flow-mediated dilation in OSA.	Brachial artery Doppler assessed nitric oxide availability before and after CPAP.	(68)
37.	Doppler is used to evaluate vascular characteristics in canine osteosarcoma.	Spectral Doppler ultrasonography assessed blood flow in tumor staging process.	(69)
38.	Doppler is used to evaluate left ventricular hypertrophy in OSA.	2D Doppler and tissue Doppler echocardiography assessed LV remodeling.	(70)
39.	Doppler is used to evaluate carotid intima-media thickness in OSA.	Common carotid Doppler ultrasonography assessed CIMT before and after surgery	(71)
40.	Doppler is used to evaluate macroangiopathy severity in OSA patients.	Ultrasound Doppler examined brachiocephalic vessel changes and blood flow velocity.	(72)
41.	Doppler is used to evaluate cardiac function in overlap syndrome patients.	Echocardiography assessed cardiovascular impact of OSA and COPD coexistence.	(73)
42.	Doppler is used to evaluate myocardial motion velocity in pediatric OSA.	Tissue Doppler imaging assessed cardiac function before and after surgery.	(74)
43.	Doppler is used to evaluate left ventricular strain in diabetes patients.	3D speckle tracking echocardiography assessed LV global strain measurements.	(75)
44.	Doppler is used to evaluate cerebrovascular compliance in obstructive sleep apnea.	Transcranial Doppler measured middle cerebral artery pulsatility index and resistance.	(76)
45.	Doppler is used to evaluate wind profiling and turbulence characteristics.	Doppler Beam Swinging analyzed wind velocity alongside spaced antenna techniques.	(77)
46.	Doppler is used to evaluate retinal vascular changes in OSA.	No specific Doppler parameters were mentioned in this study review.	(78)
47.	Doppler is used to evaluate carotid atherosclerosis in diabetic nephropathy patients.	Carotid artery color Doppler ultrasonography assessed vascular abnormalities and stenosis.	(79)
48.	Doppler is used to evaluate carotid artery medialization in 22q11.2DS.	Intraoperative Doppler ultrasound assessed carotid artery positioning during surgery	(80)
49.	Doppler is used to evaluate left ventricle wall motion in OSA.	Tissue Doppler septal velocity assessed diastolic dysfunction and cardiac remodeling.	(81)
50.	Doppler is used to evaluate endothelial dysfunction in obstructive sleep apnea.	Laser Doppler flowmetry assessed microcirculation and flow-mediated dilation changes.	(82)
51.	Doppler is used to evaluate left ventricular function in OSA.	Two-dimensional tissue Doppler imaging assessed LV strain parameters and function.	(83)
52.	Doppler is used to evaluate vascular wall changes in OSA.	Doppler ultrasound assessed cardiovascular risk and response to treatment.	(84)
53.	Doppler is used to evaluate obstructive sleep apnea events via radar.	Microwave Doppler radar analyzed breathing patterns and sleep postures.	(85)
54.	Doppler is used to evaluate haemodynamic changes in Fontan patients with OSA.	Echocardiographic Doppler measured stroke volume and peripheral venous pressure.	(86)
55.	Doppler is used to evaluate cardiac structure in hypertensive OSA patients.	Cardiac color Doppler ultrasound assessed left atrium and ventricular changes.	(87)
56.	Doppler is used to evaluate pulmonary embolism risk in OSA patients.	No specific Doppler parameters were mentioned in this study review.	(88)
57.	Doppler is used to evaluate carotid intima-media thickness in OSA.	Carotid artery ultrasound assessed arterial stiffness and elasticity parameters.	(89)
58.	Doppler is used to evaluate left ventricular myocardial deformation in OSA.	Doppler myocardial imaging and 2D speckle tracking echocardiography assessed LV function.	(90)
59.	Doppler is used to evaluate right ventricle diastolic dysfunction in OSA.	Echocardiographic Doppler assessed trans-tricuspid E-wave deceleration time correlations.	(91)
60.	Doppler is used to evaluate paradoxical breathing patterns in OSA patients.	Microwave Doppler radar analyzed respiratory features for identity	(92)

		authentication.	
61.	Doppler is used to evaluate cerebral vasoreactivity impairment in stroke patients.	Transcranial Doppler measured breath-holding index and visual evoked flow velocity.	(93)
62.	Doppler is used to evaluate oxygen saturation measurements in OSA patients.	Microwave Doppler radar analyzed respiratory chest displacements for SpO2 predictions.	(94)
63.	Doppler is used to evaluate pulmonary hypertension and LV dysfunction in OHS.	No specific Doppler parameters were mentioned in this study review.	(95)
64.	Doppler is used to evaluate cerebral blood flow velocity in OSA.	Transcranial Doppler measured middle cerebral artery flow during breath-hold tests.	(96)
65.	Doppler is used to evaluate cerebral vascular dynamics in OSA patients.	Transcranial Doppler measured breath-holding index, mean blood flow velocity, pulsatility.	(97)
66.	Doppler is used to evaluate cardiac mechanical function in OSA patients.	Speckle-tracking and conventional echocardiography assessed LV and RV function.	(98)
67.	Doppler is used to evaluate endothelial dysfunction in obstructive sleep apnea.	Laser-Doppler flowmetry assessed endothelial response and arterial tone regulation	(99)
68.	Doppler is used to evaluate obstructive sleep apnea events non-contactly.	Doppler radar analyzed waveform characteristics for breathing and movement detection.	(100)
69.	Doppler is used to evaluate sleep monitoring in aging OSA patients.	Doppler radar analyzed non-contact methods for sleep health assessments.	(101)
70.	Doppler is used to evaluate cerebral hemodynamics in OSA patients.	Transcranial Doppler ultrasound measured blood flow velocity and pulsatility index.	(102)
71.	Doppler is used to evaluate diastolic dysfunction in high-risk OSA patients.	Transthoracic Doppler echocardiography assessed left atrial volume and function indices.	(103)
72.	Doppler is used to evaluate right ventricular dysfunction in OHS patients.	Transthoracic echocardiographic Doppler assessed right ventricular systolic pressure and function.	(104)
73.	Doppler is used to evaluate right-to-left shunting in PFO-OSA patients.	Contrast-enhanced transcranial Doppler ultrasound assessed cerebral circulation abnormalities.	(105)
74.	Doppler is used to evaluate right ventricular function in OSA children.	Tissue Doppler echocardiography assessed tricuspid annular excursion and myocardial performance index	(106)
75.	Doppler is used to evaluate retrobulbar blood flow in severe OSA.	Color Doppler ultrasound measured central retinal and ophthalmic artery velocities	(107)
76.	Doppler is used to evaluate left atrial enlargement in OHS patients.	No specific Doppler parameters were mentioned in this study review.	(108)
77.	Doppler is used to evaluate cardiac structural changes in stroke patients.	Echocardiographic Doppler measured left ventricle mass index and atrial enlargement.	(109)
78.	Doppler is used to evaluate autonomic dysfunction-related apnea episodes in OSA.	No specific Doppler parameters were mentioned in this study review.	(110)
79.	Doppler is used to evaluate cerebral blood flow velocity in OSA children.	Transcranial Doppler ultrasound assessed cerebral velocity changes following adenotonsillectomy.	(111)
80.	Doppler is used to evaluate sleep-disordered breathing and limb movements in patients.	Non-contact Doppler detected body movements for apnea-hypopnea index estimation.	(112)
81.	Doppler is used to evaluate vascular endothelial dysfunction in OSA patients.	No specific Doppler parameters were mentioned in this study review.	(113)
82.	Doppler is used to evaluate ventricular dysfunction in obstructive sleep apnea patients.	Tissue Doppler and speckle-tracking echocardiography analyzed ventricular strain abnormalities.	(114)
83.	Doppler is used to evaluate blood pressure and apnea severity in OSA.	Echocardiographic Doppler assessed global longitudinal strain in hypertension-treated patients.	(115)
84.	Doppler is used to evaluate left ventricular torsion changes in OSA.	Speckle-tracking echocardiography analyzed left ventricular rotation and torsion alterations.	(116)
85.	Doppler is used to evaluate coronary flow reserve in OSA patients.	Doppler echocardiography measured coronary peak flow velocities before and after infusion.	(117)
86.	Doppler is used to evaluate obstructive sleep apnea events non-contactly.	Doppler radar analyzed body movement cancellation for apnea event detection.	(118)
87.	Doppler is used to evaluate right ventricular dysfunction in OSA	Speckle tracking and 3D echocardiography assessed RV	(119)

	patients.	strain and function.	
88.	Doppler is used to evaluate diastolic function in CAD-OSA patients.	Echocardiographic Doppler measured left atrium size and diastolic relaxation velocity.	(120)
89.	Doppler is used to evaluate range resolution improvements in radar systems.	Chirp microwave waveform analyzed Doppler resolution using optical fiber phase shifts.	(121)
90.	Doppler is used to evaluate ventricular dysfunction in severe OSA patients.	Tissue Doppler and speckle-tracking echocardiography analyzed left ventricular strain.	(122)
91.	Doppler is used to evaluate pulmonary hypertension prevalence in OHS patients.	Transthoracic echocardiographic Doppler measured systolic pulmonary artery pressure levels.	(122)
92.	Doppler is used to evaluate right ventricular alterations in OSA patients.	Tissue Doppler imaging assessed myocardial performance, fractional area change, and excursion.	(123)
93.	Doppler is used to evaluate renal artery flow in OSA patients.	Doppler imaging analyzed renal circulation in hypertensive obstructive sleep apnea patients.	(124)
94.	Doppler is used to evaluate right ventricular dysfunction in OSA patients.	Echocardiographic Doppler assessed myocardial velocity, wall thickness, and ventricular performance.	(125)
95.	Doppler evaluates airflow dynamics and pharyngeal collapse during sleep apnea	Doppler specifications include radar-based non-contact monitoring for respiratory assessment	(126)
96.	Doppler evaluates myocardial perfusion and endothelial function in OSA patients	Doppler specifications include radar-based non-contact monitoring for cardiovascular assessment	(127)
97.	Doppler evaluates fluid velocity measurement using optical coherence tomography techniques	Doppler specifications include computational filtering and unwrapping for velocity map accuracy	(128)
98.	Doppler evaluates tricuspid annular motion and right heart dysfunction detection	Doppler specifications include tissue Doppler velocity and E/e′ wave ratio.	(129)
99.	Doppler evaluates pulmonary artery pressure and endothelial dysfunction in OSA	Doppler specifications include transthoracic echocardiography for pulmonary hypertension assessment	(130)
100.	Doppler evaluates myocardial performance and ventricular function in OSA patients	Doppler specifications include tissue Doppler imaging for ventricular function assessment	(131)
101.	Doppler evaluates vascular flow and tissue perfusion in diabetic foot ulcers	Doppler specifications include spectral waveform analysis for ulcer healing prediction	(132)
102.	Doppler evaluates left atrial appendage function and thromboembolic risk in OSA	Doppler specifications include tissue Doppler imaging and transesophageal echocardiography	(133)
103.	Doppler evaluates cardiac valve function and perioperative risks in OSA patients.	Doppler specifications include echocardiographic assessment for valve replacement surgery monitoring	(134)
104.	Doppler evaluates pulmonary artery dilation and right ventricular function in OSA	Doppler specifications include acceleration time and tricuspid annular systolic velocity wave	(135)
105.	Doppler evaluates atrial conduction time and reverse atrial remodelling in OSA	Doppler specifications include PA tissue Doppler imaging for atrial assessment	(136)
106.	Doppler evaluates left atrial volume index and diastolic function in OSA	Doppler specifications include tissue Doppler imaging for left atrial assessment.	(137)
107.	Doppler evaluates internal jugular vein hemodynamics in sleep apnea patients	Doppler specifications include duplex ultrasonography for venous flow and reflux analysis	(138)
108.	Doppler evaluates peripheral arterial disease prevalence and vascular stiffness in OSA	Doppler specifications include duplex ultrasonography and pulse wave velocity analysis	(139)
109.	Doppler evaluates droplet size variation and stability in emulsions	Doppler specifications include laser Doppler velocimetry for zeta potential measurement	(140)
110.	Doppler evaluates pulmonary embolism severity and thromboembolic risk in OSA patients	Doppler specifications include venous duplex ultrasonography for thrombus detection and assessment	(141)
111.	Doppler evaluates respiratory motion and sleep apnea detection using radar sensing	Doppler specifications include continuous-wave radar at 2.45 GHz	(141)

		for monitoring	
112.	Doppler evaluates rovibrational spectra and molecular absorption in dual-comb spectroscopy	Doppler specifications include frequency combs spanning 4 THz for spectral resolution	(142)
113.	Doppler evaluates flow rate velocity and speed measurement in microfluidics	Doppler specifications include laser Doppler velocimetry for precise flow rate detection	(143)
114.	Doppler evaluates sub-Doppler transmission and electromagnetically induced transparency effects	Doppler specifications include pump-probe V-type plasmonic-atomic hybrid system analysis	(144)
115.	Doppler evaluates helium transitions and spectral resolution in fluorescence spectroscopy	Doppler specifications include a one-watt laser system at 588 nm	(145, 146)
116.	Doppler evaluates myocardial performance and pulmonary artery pressure in CPAP treatment.	Doppler specifications include tissue Doppler imaging for cardiac function assessment	(147, 148)
117.	Doppler evaluates endothelial function and vascular response in sleep apnea patients	Doppler specifications include laser Doppler flowmetry for endothelial function assessment	(149)
118.	Doppler evaluates myocardial performance and pulmonary artery pressure in CPAP therapy.	Doppler specifications include tissue Doppler imaging for cardiac function assessment.	(150)
119.	Doppler evaluates pulmonary hypertension and circulatory effects in obstructive sleep apnea	Doppler specifications include echocardiographic assessment for pulmonary artery pressure estimation	(151)
120.	Doppler evaluates blood pressure response and vascular function in voluntary apnea	Doppler specifications include brachial artery blood flow velocity measurement via ultrasound.	(152)
121.	Doppler evaluates ventricular systolic and diastolic function in OSA patients	Doppler specifications include tissue Doppler imaging for ventricular function assessment	(153)
122.	Doppler evaluates right-to-left shunting and apnea severity in OSA patients	Doppler specifications include transcranial Doppler bubble study for shunt detection	(154)
123.	Doppler evaluates 3D flow visualization and velocity measurement in microfluidics	Doppler specifications include phase-resolved optical coherence tomography for flow characterization	(155)
124.	Doppler evaluates subclinical left ventricular dysfunction in obstructive sleep apnea patients	Doppler specifications include tissue Doppler imaging and Tei index assessment	(156)
125.	Doppler evaluates left ventricular function and cardiac response in OSA therapy	Doppler specifications include pulsed wave Doppler for ventricular function assessment	(157)
126.	Doppler evaluates diastolic dysfunction and left ventricular filling pressure in OSA	Doppler specifications include tissue Doppler imaging for ventricular function assessment	(158)
127.	Doppler evaluates ballistic material characterization and weaving pattern classification	Doppler specifications include high-speed ESPI and laser Doppler vibrometry analysis	(159)
128.	Doppler evaluates vascular lesion imaging and tumor growth detection	Doppler specifications include optical coherence tomography for high-resolution vascular imaging.	(160)
129.	Doppler evaluates endothelial dysfunction and vascular changes in sleep fragmentation	Doppler specifications include transcranial Doppler for cerebrovascular reactivity assessment	(161)
130.	Doppler evaluates emission processes in inhomogeneously broadened gas lasers	Doppler specifications include quantum frequency analysis for transition level assessment	(162)
131.	Doppler evaluates pulmonary arterial pressure and right heart changes in OSA	Doppler specifications include echocardiographic assessment for cardiac structure and function analysis	(163)
132.	Doppler evaluates Young modulus measurement accuracy and signal processing improvements	Doppler specifications include multi-beam laser heterodyne and frequency modulation techniques	(164, 165)
133.	Doppler evaluates cardiac output and oxygen consumption in pediatric OSA patients	Doppler specifications include cardiac Doppler imaging for cardiopulmonary function assessment	(166)
134.	Doppler evaluates physiological monitoring and sleep analysis using radar technology	Doppler specifications include dual-frequency radar at 2.45 GHz and 24 GHz.	(167)

135.	Doppler evaluates cerebrovascular reactivity and vasomotor function in obese individuals	Doppler specifications include transcranial Doppler for breath-holding index measurement	(168)
136.	Doppler evaluates molecular transitions and saturation effects in THz spectroscopy	Doppler specifications include THz QCL radiation coupled to an optical cavity	(169)
137.	Doppler evaluates zebrafish tissue and vasculature, analyzing velocity and amplitude contrast.	Laser Doppler imaging with upright microscope, assessing velocity norm and direction.	(170)
138.	Doppler evaluates microstructured fiber's internal composition using side-scattering analysis	Laser beam illumination with frequency-modulated scattering, inverse Radon transform applied.	(171)
139.	Doppler evaluates seafloor topography in turbid water using vibrometry technology	All-fiber compact homodyne laser Doppler setup tested in anechoic tank.	(171)
140.	Doppler evaluates high-velocity detection using two-state laser self-mixing principles	Compact two-state laser with quantum-dot carrier coupling for Doppler signal.	(172)
141.	Doppler evaluates velocity filtering using beat frequency dependence of particle movement.	Spherical wave extraction with numerical verification of velocity filtering principle.	(173)
142.	Doppler evaluates neurovascular activation using FD-OCT for tissue flow analysis	FD-OCT system with Doppler frequency spectrum for vascular contrast enhancement.	(174)
143.	Doppler evaluates cardiac and vascular stiffness in patients with OSA and HHT	Echocardiographic Doppler parameters assess elastance and ventricular-arterial interaction improvements.	(175)
144.	Doppler evaluates sensitivity improvements in all-optical Faraday-rotation magnetometer studies.	Probe light frequency tuned to Doppler profile wings with cesium atoms.	(176)
145.	Doppler evaluates subclinical cardiac disturbances in ATH patients using echocardiography.	Tissue Doppler imaging assesses myocardial performance indices for RV and LV.	(177)
146.	Doppler evaluates endothelial dysfunction in pediatric OSA using flowmetry techniques.	Laser Doppler flowmetry assesses Tmax for post-occlusive hyperaemia alterations.	(178)
147.	Doppler evaluates atrial conduction delays in OSA patients using imaging techniques.	Tissue Doppler imaging measures inter- and intraatrial electromechanical conduction times.	(179)
148.	Doppler evaluates LV diastolic and systolic dysfunction in OSA patients.	Tissue Doppler imaging assesses mitral valve flow and relaxation parameters.	(180)
149.	Doppler evaluates left atrial function in OSA patients receiving CPAP therapy.	Two-dimensional speckle-tracking echocardiography assesses strain, emptying volume, and filling pressure.	(181)
150.	Doppler evaluates epicardial fat thickness and leptin levels in OSA patients.	Parasternal echocardiographic imaging measures fat thickness in different OSA severities.	(182)
151.	Doppler evaluates cardiac function and prognostic impact of OSA in STEMI.	Doppler echocardiography assesses myocardial hypertrophy and adverse cardiac event risks.	(183)
152.	Doppler evaluates coronary endothelial dysfunction and cardiovascular risk in OSA patients.	Invasive Doppler vasomotor study assesses coronary diameter and blood flow changes.	(184)
153.	Doppler evaluates cerebrovascular reactivity changes in OSA patients under hypercapnic conditions.	Middle cerebral artery blood flow velocity measured with Doppler under hypoxia.	(185)
154.	Doppler evaluates methane absorption spectra using a tunable OPO spectrometer system.	Mode-hop-free tunable ppMgCLN-OPO emitting in the 3.3-3.4 μm range.	(186)
155.	Doppler evaluates upper atmospheric winds using DASH interferometer for satellite observations.	Doppler Asymmetric Spatial Heterodyne interferometer detects O[1D] 630 nm emission.	(187)
156.	Doppler evaluates flexural vibrations in micromechanical cantilever beams in ambient air.	Laser Doppler vibrometer characterizes vibrations under symmetrical electrode actuation.	(188)
157.	Doppler evaluates ground-moving-target detection and tracking using radar testbed technology.	Pulse-Doppler processing with AESA antenna tracks vehicles and dismount targets.	(189)
158.	Doppler evaluates sleep-disordered breathing prevalence in patients undergoing TAVI for AS.	Cardiorespiratory polygraphy with apnea-hypopnea index assesses sleep apnea severity.	(190)
159.	Doppler evaluates left ventricular mass in morbidly obese patients with OSA.	Polysomnographic and echocardiographic Doppler imaging assess LVM and cardiovascular risk.	(191)
160.	Doppler evaluates plasmonic pulses and relativistic radiation induced by laser excitation.	90-fs laser pulse generates undulator-like radiation with Doppler shift	(192)

		effects.	
161.	Doppler evaluates back-scattering intensity, Doppler shift, and phase retardation.	Jones matrix tomography measures three-dimensional Jones matrices distribution.	(35)
162.	Doppler evaluates saturated absorption spectroscopy inside a C2H2-filled hollowcore fiber.	Single optical frequency comb at 1532.83 nm amplified for spectroscopy.	(193)
163.	Doppler evaluates plasma instability enhancement leading to superradiant terahertz emission.	Asymmetric chirped dual-grating-gate transistors generate Doppler-driven 3.55 THz emission.	(194)
164.	Doppler evaluates cell migration tracking using magnetomotive OCT for retinal pathologies.	Phase-resolved Doppler OCT analyzes nanoparticle-labeled cells with magnetomotive imaging.	(19, 20)
165.	Doppler evaluates phase-stable imaging improvements in DEFR optical coherence tomography.	Advanced DEFR algorithm enables Doppler measurements using Fourier transform processing.	(14, 15)
166.	Doppler evaluates vascular function improvements in obese OSA patients undergoing treatment.	Laser Doppler flowmetry measures skin blood flow changes and microvascular reactivity.	(195)
167.	Doppler evaluates vertebrobasilar system changes in adults with and without OSA.	Doppler ultrasonography measures vertebral artery diameter, flow volume, and resistive index.	(196)
168.	Doppler evaluates right-to-left shunting prevalence in OSA patients with PFO.	Contrast transcranial Doppler ultrasonography assesses shunt size with Valsalva provocation.	(197)
169.	Doppler evaluates LV diastolic dysfunction in non-obese male OSA patients.	Tissue Doppler imaging assesses transmitral flow velocity and mitral annular velocity	(198)
170.	Doppler evaluates diastolic dysfunction severity in patients with obstructive sleep apnea.	Tissue Doppler echocardiography assesses left ventricular function and apnea severity.	(199)
171.	Doppler evaluates functional hyperemia and retinal blood flow in rats	Spectral domain OCT with speckle decorrelation generates OCT angiograms.	(200)
172.	Doppler evaluates flow quantification, vasculature imaging, vibration organ analysis, and elastography.	Doppler OCT advancements improve applications in vascular imaging and functional assessment.	(201)
173.	Doppler evaluates aerosol extinction and backscatter in atmospheric remote sensing studies.	Doppler Michelson Interferometer replaces Fabry-Perot for spectral discrimination improvements.	(202)
174.	Doppler evaluates ultraviolet transition frequencies in antiprotonic helium atoms with spectroscopy.	Sub-Doppler two-photon laser spectroscopy measures transition precision for CPT symmetry testing.	(203)
175.	Doppler evaluates vibration amplitudes using Fourier and Time domain detection.	Higher-order Bessel functions process Doppler signals with broadened bandwidth	(204)
176.	Doppler evaluates vibration amplitudes using Fourier and Time domain detection.	Higher-order Bessel functions process Doppler signals with broadened bandwidth.	(205)
177.	Doppler evaluates tympanic membrane oscillation patterns for sound transmission analysis.	M-scans encode oscillatory movement in Doppler signals for functional imaging.	(27)
178.	Doppler evaluates phase-stable imaging improvements in DEFR optical coherence tomography.	Advanced DEFR algorithm enables Doppler measurements using Fourier transform processing.	(14, 15)
179.	Doppler evaluates gingival blood flow changes following laser reshaping treatments.	Laser Doppler Flowmetry monitors microvascular perfusion using MoorLab optical probe system	(206)
180.	Doppler evaluates vibration amplitudes using Fourier and Time domain detection.	Higher-order Bessel functions process Doppler signals with broadened bandwidth.	(204)
181.	Doppler evaluates scattering tomography and polarization properties of the sample.	Jones matrix tomography enables Doppler measurements with polarization analysis capabilities.	(34)
182.	Doppler evaluates multiplex two-photon excitation spectra using Fourier transform spectroscopy.	Doppler-free Fourier transform spectroscopy employs two ultrashort pulse lasers for detection.	(207)
183.	Doppler evaluates early atherosclerotic lesions in OSA patients without comorbidities.	Transcranial Doppler ultrasound measures carotid intima media thickness and vascular stenosis.	(208)
184.	Doppler evaluates endothelial dysfunction linked to epigenetic modifications in pediatric OSA.	Laser Doppler flowmetry assesses vascular response time during postocclusive hyperemia.	(209)
185.	Doppler evaluates cardiovascular changes in children	Echocardiographic Doppler assesses heart	(210)

	with OSA after adenotonsillectomy.	function, pulmonary pressures, and blood flow.	
186.	Doppler evaluates PFO prevalence and nocturnal desaturation in severe OSA patients.	Transcranial Doppler detects shunt size and assesses contrast echocardiography results.	(211)
187.	Doppler evaluates coherent LIDAR performance using a high-power laser amplifier system.	Er, Yb:glass planar waveguide enables pulsed Doppler amplification with high gain.	(212, 213)
188.	Doppler evaluates velocity measurement using dual-frequency laser Doppler velocimetry technique.	Optically-injected semiconductor laser reduces speckle noise and spectral broadening effects.	(214)
189.	Doppler evaluates spatial properties of harmonics generated on plasma mirrors.	Analytical modeling examines Doppler harmonics for attosecond pump-probe applications.	(215, 216)
190.	Doppler evaluates high-energy Rydberg levels in atomic xenon excitation spectra.	Sub-Doppler two-photon spectroscopy uses narrowband nanosecond pulses at 206-210 nm.	(217, 218)
191.	Doppler evaluates rovibronic spectra of iodine using dual-comb spectroscopy techniques.	Doppler-limited resolution achieved within 12 ms using free-running lasers.	(219, 220)
192.	Doppler evaluates xenon single photon transitions using vacuum-UV frequency comb	Doppler-free atomic beam excites xenon at 147 nm wavelength.	(221, 222)
193.	Doppler is used to evaluate longitudinal and transversal frequency shifts.	Spatially-varying phase induces transversal Doppler shift for enhanced motion detection.	(223)
194.	Doppler is used to evaluate vector velocity and altitude for navigation.	Fiber-based coherent Doppler lidar ensures precision for planetary vehicle landings.	(224)
195.	Doppler is used to evaluate imaging in frequency-shifting angiography applications.	Laser Doppler imaging supports auto-focusing, magnification, and video-rate reconstruction.	(225)
196.	Doppler is used to evaluate fluid velocity profiles near actuators.	Two-component laser Doppler system achieves high-resolution measurement at 20 µm.	(226)
197.	Doppler is used to evaluate myocardial dysfunction in OSA patients.	Tissue Doppler echocardiography assesses strain rates and ventricular function changes.	(227)
198.	Doppler is used to evaluate retrolingual obstruction in OSAS patients.	No specific Doppler specifications mentioned in the study's	(228)
		methodology.	
199.	Doppler is used to evaluate heart function in OSA patients.	Cardiac Doppler ultrasound measures ventricular function, Tei index, and pressures.	(229)
200.	Doppler is used to evaluate right-to-left shunting in OSA patients.	Transcranial Doppler ultrasound detects PFO using agitated saline injection method.	(230)
201.	Doppler is used to evaluate right-to-left shunting in OSA patients.	Transcranial Doppler ultrasound detects PFO using agitated saline injection method.	(231)
202.	Doppler is used to evaluate left ventricular mass and function.	Doppler echocardiography calculates myocardial performance index using contraction-relaxation timing.	(232)
203.	Doppler is used to evaluate left ventricular structural changes in OSA.	Tissue Doppler echocardiography measures mitral valve tenting and diastolic function.	(233)
204.	Doppler is used to evaluate left ventricular function in OSA patients.	Tissue and transcranial Doppler imaging assess systolic, diastolic, and structural changes.	(234)
205.	Doppler is used to evaluate atrial electromechanical delay in OSA.	Tissue Doppler imaging measures atrial conduction delay and mechanical alterations.	(235)
206.	Doppler is used to evaluate endothelial function in OSA patients.	No specific Doppler specifications mentioned for ischemic reactive hyperemia assessment.	(236)
207.	Doppler is used to evaluate precision shifts in laser anemometry.	Weak values technique achieves Doppler shift measurement down to 1 microHz.	(237)
208.	Doppler is used to evaluate harmonic spatial properties on plasma mirrors.	Analytical modeling examines Doppler harmonic behavior for attosecond pump-probe experiments.	(215, 216)
209.	Doppler is used to evaluate wind profiles in the atmosphere.	Pulsed coherent Doppler lidar operates at 50µJ, 500ns, 10kHz repetition.	(238)
210.	Doppler is used to evaluate fiber optics for IR spectroscopy.	Multi-mode fiber with 60-µm core tested for image coupling.	(239)
211.	Doppler is used to evaluate microvascular imaging in skin diseases.	Swept-source OCT system operates at 1300nm with 440kHz A-scan rate.	(240)

212.	Doppler is used to evaluate vascular reactivity in aging rats.	Doppler OCT measures vessel reactivity and pulsatility under gas challenges.	(241)
213.	Doppler is used to evaluate color reconstruction in digital holography.	Doppler phase-shifting records three color components with a monochromatic camera.	(242)
214.	Doppler is used to evaluate retinal flow imaging in vivo.	Fiber-based optical coherence tomography uses Jones matrix detection for measurements.	(33)
215.	Doppler is used to evaluate small vibration measurements using holography.	Laser Doppler vibrometer enables precise vibration detection alongside interferometry techniques.	(243)
216.	Doppler is used to evaluate electromagnetically induced transparency in atomic systems.	Doppler broadening influences wave-vector mismatches in four-level Y-type configurations.	(244)
217.	Doppler is used to evaluate subclinical right ventricular dysfunction in OSA.	Speckle tracking echocardiography assesses strain rates in the RV free wall.	(245)
218.	Doppler is used to evaluate effects in femtosecond pulse excitation.	Coherent control eliminates Doppler effects for precision frequency comb spectroscopy.	(246)
219.	Doppler is used to evaluate subclinical left ventricular dysfunction in OSA.	Speckle tracking echocardiography assesses longitudinal strain with automated function imaging.	(247)
220.	Doppler is used to evaluate vector velocity and altitude navigation.	Coherent Doppler lidar enables precision landing using velocity and altitude data.	(248)
221.	Doppler is used to evaluate blood flow and oxygen levels in tissue.	Laser Doppler flowmetry enables simultaneous measurements of Hb, SO2, and perfusion.	(249, 250)
222.	Doppler is used to evaluate flow velocity in spectral domain OCT.	Joint spectral and time domain OCT uses 2D FFT analysis.	(18)
223.	Doppler is used to evaluate blood flow contrast in retinal vessels.	Phase-shifting technique enhances perfused vessel imaging in human retina scans.	(251)
224.	Doppler is used to evaluate rotational effects in noninertial reference frames.	Phase-conjugating interferometer uses photorefractive mirror to create helical patterns.	(252)
225.	Doppler is used to evaluate OCT flow information using automation.	Support vector machine employs histogram equalization for vessel classification	(253)
		accuracy.	
226.	Doppler is used to evaluate optical enhancement in plasmon resonance systems.	No specific Doppler specifications mentioned for plasmon resonance or scattering effects.	(254)
227.	Doppler is used to evaluate fluorescence polarization in photosynthetic pigments.	No specific Doppler specifications mentioned for absorption or fluorescence spectra.	(11, 255, 256)
228.	Doppler is used to evaluate choroidal vascular reactivity in OSA patients.	Laser Doppler flowmetry measures subfoveal choroidal blood flow during exercise changes.	(257)
229.	Doppler is used to evaluate kidney microcirculation in rat models.	3D Doppler OCT detects dynamic blood flow changes in real time.	(258)
230.	Doppler is used to evaluate deep brain surgery guidance using OCT.	OCT needle device operates at 16 frames/second with 21-gauge size.	(259)
231.	Doppler is used to evaluate blood tissue perfusion and oxygen saturation.	Laser Doppler flowmetry enables Hb, SO2, and blood flow measurements simultaneously.	(249, 250)
232.	Doppler is used to evaluate electromechanical coupling in atrial function.	Tissue Doppler imaging measures atrial delays and P-wave dispersion.	(260)
233.	Doppler is used to evaluate pulmonary hypertension in MPS VI patients.	Doppler echocardiography assesses cardiovascular effects and oxygen desaturation correlations.	(261)
234.	Doppler is used to evaluate coronary microcirculation impairment in OSA patients.	Doppler guidewire measures coronary flow velocity and myocardial tissue perfusion.	(262)
235.	Doppler is used to evaluate renal haemodynamics impairment in OSA patients.	Colour duplex ultrasound measures renal resistance index in mild-to-moderate OSA.	(263)
236.	Doppler is used to evaluate posterior eye angiography non-invasively.	High-speed, high-sensitive Doppler OCT enables detailed retinal investigations.	(30)
237.	Doppler is used to evaluate cooling of optically levitated particles.	Doppler cooling technique assists in stabilizing particles in fiber traps.	(264)
238.	Doppler is used to evaluate blood refractive index variations dynamically.	Doppler OCT detects measurement changes influenced by refractive index shifts.	(265)
239.	Doppler is used to	Coherent dual-	(266)

	evaluate methane spectral lines with precision.	comb spectrometer measures line-center frequency with 300 kHz accuracy.	
240.	Doppler is used to evaluate upper atmospheric wind observations precisely.	Doppler Asymmetric Spatial Heterodyne interferometer analyzes O[1D] 630 nm emission data.	(267)
241.	Doppler is used to evaluate upper atmospheric winds passively.	DASH optical spectrometer reviews prototype and field campaign performance data.	(268)
242.	Doppler is used to evaluate cerebral blood flow changes in mice.	Laser Doppler flowmetry measures CBF variations alongside speckle flowgraphy techniques.	(269)
243.	Doppler is used to evaluate carotid atherosclerosis and plaque formation.	Doppler ultrasound determines plaque presence and intima-media thickness exceeding 0.9 mm.	(270)
244.	Doppler is used to evaluate plasma grating velocity in filament interactions.	Doppler effect analyzes traveling plasma grating speed formed between filaments.	(271)
245.	Doppler is used to evaluate vertebrobasilar insufficiency's link to OSA.	Doppler sonography assesses VB system circulation with positional functional tests.	(272)
246.	Doppler is used to evaluate sleep-disordered breathing effects on heart function.	Echocardiography with Doppler assesses left ventricular performance in HCM patients.	(273)
247.	Doppler is used to evaluate vascular dysfunction linked to OSA and diabetes.	Laser Doppler flowmetry assesses skin microcirculation and brachial artery function.	(274)
248.	Doppler is used to evaluate microcirculatory endothelial dysfunction in OSA patients.	No specific Doppler specifications mentioned for endothelial function assessment.	(275)
249.	Doppler is used to evaluate myocardial performance changes due to OSA.	Tissue Doppler imaging measures left and right ventricular myocardial indices.	(276)
250.	Doppler is used to evaluate tricuspid regurgitation and pulmonary hypertension.	Doppler pulse wave measures correlations between CRP levels and TR severity.	(277)
251.	Doppler is used to evaluate vascular dysfunction caused by OSA.	Laser Doppler flowmetry measures skin microcirculation alongside brachial artery ultrasound.	(278)
252.	Doppler is used to evaluate left ventricular dysfunction in OSA patients.	Doppler echocardiography measures myocardial performance index and ventricular mass changes.	(279)
253.	Doppler is used to evaluate choroidal vascular reactivity in OSA patients.	Choroidal laser Doppler flowmetry measures subfoveal blood flow velocity and volume.	(280)
254.	Doppler is used to evaluate skeletal muscle vasodilation in hypoxic OSA patients.	Doppler ultrasound measures femoral artery blood flow under hypoxic conditions.	(281)
255.	Doppler is used to evaluate cerebral blood flow changes in OSA patients.	Transcranial Doppler ultrasound measures cerebral blood flow and CO2 reactivity.	(282)
256.	Doppler is used to evaluate wave damping influenced by surface films.	Doppler shift analyzes optical spectrum variations due to nonlinear distortions.	(283)
257.	Doppler is used to evaluate subclinical right ventricular dysfunction in OSA.	Tissue Doppler imaging measures RV isovolumic acceleration and myocardial deformation.	(284)
258.	Doppler is used to evaluate left heart function changes in OSA.	Doppler echocardiography measures left ventricular ejection fraction and E/A ratio.	(285)
259.	Doppler is used to evaluate high-resolution target detection capabilities.	Doppler resolution enhances radar performance within ultra-wideband waveform design.	(286)
260.	Doppler is used to evaluate blood flow separation in optical tomography.	Doppler Fourier domain OCT utilizes histograms for precise flow differentiation.	(287, 288)
261.	Doppler is used to evaluate brain perfusion during open surgery.	Laser Doppler imaging detects functional brain maps with strong contrast.	(289, 290)
262.	Doppler is used to evaluate systolic blood flow velocities in mice.	Doppler OCT estimates flow sensitivity affected by motion-induced signal fading.	(16, 17)
263.	Doppler is used to evaluate dynamic blood flow in OCT imaging.	Resonant Doppler flow imaging enhances velocity estimation using piezo-controlled mirrors.	(23, 24)
264.	Doppler is used to evaluate optical angiography imaging in OCT systems.	Doppler phase-shift simulation refines velocity threshold adjustments in	(21, 22)

		post-processing.	
265.	Doppler is used to evaluate alveolar blood flow in lung tissue.	OCT Doppler imaging measures alveolar arterioles using swept-source tomography.	(12, 13)
266.	Doppler is used to evaluate pulsatile arterial blood flow in mice.	Phase-resolved Doppler OFDI measures time-resolved flow in 300 μm vessels.	(25, 26)
267.	Doppler is used to evaluate high-sensitive optical coherence angiography in eyes.	Phase-resolved spectral-domain Doppler OCT acquires tomograms with dual beams.	(28, 29)
268.	Doppler is used to evaluate left atrium function and diastolic performance.	Tissue Doppler imaging assesses LA volumes and LV diastolic function.	(291, 292)
269.	Doppler is used to evaluate blood microcirculation in skin and mucosa.	Laser Doppler Flowmetry assesses soft tissue function using noninvasive diagnostics.	(293, 294)
270.	Doppler is used to evaluate signal complexity changes in SAS patients.	Laser Doppler flowmetry analyzes multifractal spectra from forearm blood circulation.	(295, 296)
271.	Doppler is used to evaluate brachial artery dilation in OSA patients.	Doppler ultrasound measures flow-mediated and nitroglycerin-induced vasodilation responses.	(297)
272.	Doppler is used to evaluate left ventricular diastolic dysfunction in OSA.	Doppler echocardiography measures mitral E/A ratio changes and dysfunction risk.	(298)
273.	Doppler is used to evaluate left ventricular function changes in OSA patients.	Tissue Doppler imaging measures systolic and diastolic annular velocity variations.	(299)
274.	Doppler is used to evaluate pulmonary artery pressure in hypertrophic tonsils.	Doppler echocardiography measures systolic pulmonary artery pressure correlation with tonsil size.	(300)
275.	Doppler is used to evaluate middle cerebral artery velocity in hypercapnea.	Transcranial Doppler ultrasound measures cerebral blood flow changes under indomethacin effects.	(301)
276.	Doppler is used to evaluate left ventricular systolic and diastolic dysfunction.	Tissue Doppler imaging measures myocardial velocities, relaxation time, and acceleration.	(302)
277.	Doppler is used to evaluate right ventricular function in OSA patients.	Tissue Doppler imaging measures RV wall thickness, MPI, and IVA.	(303)
278.	Doppler is used to evaluate myocardial structural changes in OSA patients.	Tissue Doppler imaging assesses mitral annular velocity and myocardial reflectivity.	(304)
279.	Doppler is used to evaluate atrial electromechanical activation time in OSA.	Tissue Doppler imaging measures mitral annulus velocity and atrial remodeling.	(292)
280.	Doppler is used to evaluate renal and hepatic abnormalities in PICU patients.	Abdominal echo-Doppler detects renal cortical hyperechogenicity and hepatomegaly severity.	(305)
281.	Doppler is used to evaluate cerebral blood flow velocity in OSA.	Transcranial Doppler ultrasound measures cerebrovascular conductance and autoregulation response.	(306)
282.	Doppler is used to evaluate right ventricular performance in ATH patients.	Doppler echocardiography measures myocardial performance index pre- and post-adenotonsillectomy.	(307)
283.	Doppler is used to evaluate cardiac dysfunctions in children with OSA.	Tissue Doppler echocardiography measures diastolic function and inflammatory biomarkers correlation.	(308)
284.	Doppler is used to evaluate left ventricular diastolic function in OSA.	Tissue Doppler imaging measures early diastolic velocity and apnea severity.	(309)
285.	Doppler is used to evaluate sub-Doppler stabilization in acetylene gas.	Fiber laser at 1532 nm stabilizes using photonic crystal fiber system.	(310)
286.	Doppler is used to evaluate wind measurements using space-based lidar.	Coherent-detection, 2-micron pulsed Doppler lidar system enables atmospheric wind tracking.	(311)
287.	Doppler is used to evaluate left ventricular function changes in CHF patients.	Doppler echocardiography measures systolic function, stroke volume, and filling pressures.	(312)
288.	Doppler is used to evaluate right ventricular function and pulmonary hypertension.	Tissue Doppler echocardiography measures RV pressure, systolic speed, and TEI index.	(313)
289.	Doppler is used to evaluate pulmonary arterial hypertension in OSA patients.	Doppler imaging measures blood pressure changes and vasoconstriction effects in hypoxemia.	(314)
290.	Doppler is used to evaluate cerebral blood flow and skin perfusion.	Laser Doppler perfusion imaging uses high-speed CMOS-camera for rapid	(315, 316)

		mapping.	
291.	Doppler is used to evaluate retinal and choroidal vasculature imaging.	Doppler optical coherence angiography visualizes three-dimensional vascular flow structures precisely.	(31, 32)
292.	Doppler is used to evaluate fast tissue flow quantification in imaging.	Resonant Doppler Fourier Domain Optical Coherence Tomography measures vascular structures precisely.	(317, 318)
293.	Doppler is used to evaluate coronary artery development in chick embryos.	Doppler OCT imaging captures 3D heart scans and blood flow visualization.	(319, 320)
294.	Doppler is used to evaluate renal resistance index in OSA patients.	Renal duplexsonography measures end-diastolic and peak systolic velocity ratios.	(321)
295.	Doppler is used to evaluate atherosclerotic artery disease prevalence in OSA patients.	Duplex ultrasonography measures carotid bulb and internal carotid artery lesions.	(322)
296.	Doppler is used to evaluate flow velocity estimation using spectral analysis.	Spectral Optical Coherence Tomography detects oscillatory Doppler shifts in moving objects.	(323, 324)
297.	Doppler is used to evaluate right and left ventricular function.	Doppler echocardiography measures myocardial performance index and ventricular dysfunction severity.	(325)
298.	Doppler is used to evaluate myocardial contractile reserve in OSA patients.	Tissue Doppler imaging with dobutamine stress measures systolic and diastolic velocities.	(326)
299.	Doppler is used to evaluate left ventricular structure changes in OSA.	Doppler imaging calculates myocardial performance index using isovolumic contraction times.	(327)
300.	Doppler is used to evaluate carotid IMT, brachial vasodilation, and aortic elasticity parameters.	Doppler specifications used high-resolution Doppler echocardiography for vascular and aortic assessment.	(328)
301.	Doppler is used to evaluate aortic stiffness, left ventricular function, and distensibility parameters.	Doppler specifications used M-mode echocardiography for systolic and diastolic aortic measurements.	(329)
302.	Doppler is used to evaluate ventricular morphology, function, and systolic/diastolic velocities in OSA.	Doppler specifications used tissue Doppler imaging for ventricular systolic and diastolic assessment.	(330)
303.	Doppler is used to evaluate right ventricular myocardial performance index and free wall diameter.	Doppler specifications used M-mode and Doppler imaging for myocardial index calculations.	(331)
304.	Doppler is used to evaluate optical coherence tomography frequency estimation with adaptive filtering.	Doppler specifications used adaptive notch filter for frequency estimation in Doppler imaging.	(332)
305.	Doppler is used to evaluate 3D structure, polarization, and high-speed imaging in FDOCT.	Doppler specifications used swept laser for Fourier domain optical coherence tomography imaging.	(333)
306.	Doppler is used to evaluate reactive hyperemia signals for PAOD diagnosis and analysis.	Doppler specifications used laser Doppler flowmetry with principal components analysis for signal processing.	(334)
307.	Doppler is used to evaluate blood flow, tissue perfusion, and haemoglobin oxygenation changes in brain.	Doppler specifications used laser-Doppler spectroscopy with NIR wavelengths for neurovascular coupling analysis.	(335)
308.	Doppler is used to evaluate velocity profiles and scattering effects in simulated blood vessels.	Doppler specifications used Doppler optical coherence tomography for velocity deviation quantification.	(336)
309.	Doppler is used to evaluate depth-resolved localized flow velocity in scattering biological tissues.	Doppler specifications used optical Doppler tomography with multiple scattering effect analysis.	(337)
310.	Doppler is used to evaluate right-to-left shunting through a patent foramen ovale in OSAS.	Doppler specifications used echocardiography for detecting shunting and assessing structural cardiac abnormalities.	(338)
311.	Doppler is used to evaluate left ventricular diastolic dysfunction prevalence in obese OSA patients.	Doppler specifications used tissue Doppler echocardiography for left ventricular function assessment.	(339)
312.	Doppler is used to evaluate real-time imaging in optical coherence and Doppler tomography.	Doppler specifications used double-pass rotary mirror array for fast optical delay scanning.	(340)
313.	Doppler is used to	Doppler	(341)

	evaluate carotid artery intima-media thickness, plaques, and extracranial stenosis.	specifications used ultrasonography for assessing vascular changes linked to OSA.	
314.	Doppler is used to evaluate vascular resistance responses in the brachial artery under OSA conditions.	Doppler specifications used Doppler ultrasound for assessing blood flow velocity and resistance changes.	(342)
315.	Doppler is used to evaluate flow-mediated dilation and nitroglycerin-induced dilation in brachial arteries.	Doppler specifications used Doppler ultrasound for assessing vascular relaxation and endothelial function.	(343)
316.	Doppler is used to evaluate right ventricular diameter, thickness, and pulmonary ejection acceleration time.	Doppler specifications used Doppler echocardiography for right ventricular structure and pulmonary assessment.	(344)
317.	Doppler is used to evaluate intima-media thickness and plaque presence in sleep-disordered breathing.	Doppler specifications used ultrasonographic evaluation for vascular risk factor assessment.	(345)
318.	Doppler is used to evaluate lubricant displacement under flying head slider due to interaction.	Doppler specifications used optical surface analyzer for detecting slider-disk interaction effects.	(346)
319.	Doppler is used to evaluate cooling atoms below the Doppler limit in quantum mechanics.	Doppler specifications used optical pumping and light shifts in atomic cooling research.	(347)
320.	Doppler is used to evaluate right-to-left shunting prevalence in obstructive sleep apnea patients.	Doppler specifications used transcranial Doppler with saline contrast for PFO detection.	(348)
321.	Doppler is used to evaluate right and left ventricular dimensions, mass index, and geometry.	Doppler specifications used echocardiography for assessing cardiac structural changes in children with OSA.	(349)
322.	Doppler is used to evaluate pulmonary hemodynamics and vascular response in obstructive sleep apnea.	Doppler specifications used Doppler echocardiography for pulmonary artery pressure and blood flow assessment.	(10)
323.	Doppler is used to evaluate left ventricular diastolic function and relaxation pattern in OSA.	Doppler specifications used transmitral valve pulse-wave Doppler echocardiography for ventricular assessment.	(350)
324.	Doppler is used to evaluate pulmonary artery pressure and hypertension development in OSA patients.	Doppler specifications used pulsed-wave Doppler echocardiography for pulmonary pressure estimation and monitoring.	(351)
325.	Doppler is used to evaluate left ventricular mass and diastolic function in OSA patients.	Doppler specifications used echocardiography for assessing ventricular function and structural changes.	(352)
326.	Doppler is used to evaluate left ventricular myocardial function and arterial dilation in OSA.	Doppler specifications used echocardiography and ultrasonographic measurements for cardiovascular assessment.	(353)
327.	Doppler is used to evaluate left ventricular diastolic dysfunction and blood pressure changes in OSA patients.	Doppler specifications used pulsed Doppler echocardiography for measuring transmitral flow and ventricular function.	(354)
328.	Doppler is used to evaluate spatio-temporal spectra of surface waves backscattered by rough water surfaces.	Doppler specifications used Doppler scatterometers and optical spectrum analyzer for signal characterization.	(355)
329.	Doppler is used to evaluate pulmonary artery pressure and pulmonary vascular responses in OSA patients.	Doppler specifications used Doppler echocardiography for assessing pulmonary hemodynamics and cardiac output.	(356)
330.	Doppler is used to evaluate ventricular hypertrophy, wall motion abnormalities, and pulmonary hypertension in OSA.	Doppler specifications used Doppler color echocardiography for assessing ventricular structure and function during sleep-induced desaturation.	(357)
331.	Doppler is used to evaluate microcirculation disturbances in upper airway afferent nerve regulation in OSA.	Doppler specifications used laser Doppler perfusion monitoring combined with electrical stimulation methodology.	(358)
332.	Doppler is used to evaluate diastolic left ventricular function improvements following nCPAP therapy.	Doppler specifications used Doppler echocardiography for measuring transmitral flow and deceleration period.	(359)
333.	Doppler is used to	Doppler	(360)

	evaluate ventricular function and pulmonary arterial pressure in severe OSA.	specifications used two-dimensional Doppler echocardiography for cardiac output and pressure assessment.	
334.	Doppler is used to evaluate flow dynamics in Atrial Fibrillation using nonlinear signal detection.	Doppler specifications used transesophageal echocardiography with nonlinear phase space tracking metrics.	(361)
335.	Doppler is used to evaluate cardiac structure and sympathetic activity changes after CPAP treatment.	Doppler specifications used Doppler echocardiography for left ventricular mass index assessment.	(362)
336.	Doppler is used to evaluate cerebral blood flow velocity and pulsatility index during sleep apnea.	Doppler specifications used transcranial Doppler for monitoring cerebral circulation under apnea conditions.	(363)
337.	Doppler is used to evaluate left ventricular dimensions and systolic and diastolic performance.	Doppler specifications used M-mode and two-dimensional echo-Doppler for cardiac function assessment.	(364)
338.	Doppler is used to evaluate flow velocities in gases and flames scientifically.	Doppler specifications used frequency shifts and velocity profiles for gas-phase measurements.	(6)

Results and discussion

Obstructive Sleep Apnea (OSA) is a serious sleep disorder characterized by recurrent narrowing of the airways, leading to decreased oxygen in the blood and increased cardiovascular burden. Potential complications such as hypertension, heart disease, and metabolic disorders further emphasize the importance of innovation in early detection and treatment of OSA. In this context, Doppler technology has emerged as a non-invasive tool that allows real-time measurement of blood flow, providing deep insight into hemodynamic changes in OSA patients. This approach opens up new horizons in the field of diagnostics, where accuracy and speed of evaluation are critical to the quality of care(2, 10, 102, 351, 356).

The bibliometric approach applied in this study utilizes data from the Scopus database to collect all relevant literature discussing the application of Doppler technology in the diagnosis and management of OSA. This method not only examines the number of publications, but also analyzes collaboration patterns between authors, citation trends, and the geographical distribution of research conducted. Such an analysis provides a comprehensive picture of the academic landscape, revealing how research in this field is developing and potentially identifying methodological gaps for future research development(3).

The results of the literature analysis show a significant increase in the number of publications over the past two decades, especially with the adoption of advanced imaging technologies in OSA studies. This increase reflects the scientific community's response to the urgent need for more sensitive and specific diagnostic methods in measuring blood flow dynamics. This positive trend also indicates that the adaptation of Doppler technology as a diagnostic method has gained wide acceptance among international researchers, while encouraging the integration of technological innovations into daily clinical practice(3).

Further bibliometric analysis revealed a strong global collaborative network between institutions and researchers, contributing to the diversification and deepening of research in the field of OSA. Cross-disciplinary collaboration between cardiologists, radiologists and sleep medicine experts allows for a holistic methodology and more accurate data interpretation. This network not only improves the quality of publications, but also allows for synergies in technology development,

where technical knowledge from biomedical engineering meets clinical applications, resulting in transdisciplinary diagnostic innovations(3, 9, 96).

Doppler technology provides the technical advantage of real-time blood flow analysis which is essential in detecting subtle changes in the hemodynamic conditions of OSA patients. This advantage compared to conventional methods provides added value in terms of sensitivity and specificity of diagnosis, especially in detecting rapid and precise therapeutic responses. Studies published in Scopus indexed journals have consistently reported the validity of this method, thus strengthening the argument that the use of Doppler allows for better and more effective clinical decision-making(2, 10, 102, 200, 351, 356, 365, 366).

From the clinical application side, the integration of Doppler technology in OSA management not only contributes to early diagnosis, but also plays an important role in evaluating the response to therapy, such as the use of Continuous Positive Airway Pressure (CPAP). Continuous monitoring of hemodynamic parameters via Doppler allows physicians to assess the effectiveness of therapy and adjust interventions according to patient needs. Many studies have shown that this approach can be a predictive indicator of cardiovascular function improvement and reduction in the risk of complications, thus providing a scientific basis for the development of more standardized treatment protocols(7, 36, 63, 82, 86, 97, 120, 127, 147-149, 297, 327, 331, 338, 359, 362, 367).

A multidisciplinary approach is key to maximizing the potential of Doppler technology. By combining expertise in sleep medicine, imaging techniques, and bibliometric data analysis, this study creates an in-depth framework for understanding hemodynamic dynamics in OSA patients. Interdisciplinary collaboration not only paves the way for the application of new and innovative methods, but also enables the development of more personalized and adaptive diagnostic tools for complex clinical conditions. Such integration will continue to push the boundaries of science and accelerate the transfer of technology to clinical practice(368).

Although Doppler technology has shown promising results, challenges arise related to the standardization of diagnostic procedures. Differences in study design, data acquisition methods, and evaluation criteria often hinder the consolidation of existing findings in the literature. Critical evaluation through bibliometric analysis plays an important role in identifying methodological inconsistencies and establishing recommendations for more uniform standard guidelines. A global initiative to establish integrated protocols is expected to improve the reproducibility and validity of results, and support future evidence-based policymaking.

However, several limitations in the literature were revealed through in-depth analysis, including variability in sample size, differences in the populations studied, and the lack of longitudinal studies that can provide a picture of the long-term development of OSA patients. These limitations emphasize the need for more comprehensive and methodologically rigorous studies to confirm the effectiveness and accuracy of the use of Doppler technology. Thus, the criticisms and recommendations emerging from this bibliometric review are very important for establishing a more solid research foundation, while also raising the need for more standardized and large-scale experiments.

Integration of Doppler technology in the diagnosis and management of Obstructive Sleep Apnea has a significant impact in opening new insights into the dynamics of patient hemodynamics, while optimizing treatment strategies through diagnostic innovation. The results of the bibliometric analysis highlight the important role of international collaboration, the development of advanced technologies, and a multidisciplinary approach in defining future research directions. The recommendations generated emphasize the need for further research that focuses on standardized protocols, more in-depth evaluation of hemodynamic parameters, and strengthening the network between researchers and practitioners to achieve optimal and sustainable clinical outcomes.

Conclusions

The review underscores the vital integration of Doppler technology in enhancing the diagnostic and therapeutic strategies for OSA. This bibliometric analysis not only establishes a comprehensive map of existing literature but also identifies key areas needing further exploration. It emphasizes the necessity for continued collaboration amongst academic, clinical, and technological domains to refine the standard of care for individuals afflicted by this widespread condition.

Ultimately, the insights gleaned from this study reinforce the transformative potential that advances in hemodynamic understanding and Doppler technology hold for the field of sleep medicine. Future studies are encouraged to build upon these foundations, assuring robust methodologies and collaborative frameworks that will enhance OSA management and care.

Data availability statement

No Data Associated with this manuscript.

Software availability

VOSviewer software is an open-access tool that can be used as a cost-effective method for any scientometric analysis Biblioshiny

Author Contribution

AYS conducts research, gathers data, performs statistical analysis, and produces discussions and conclusions, DAYS, RV and TDS editing.

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