# Research Status and Prospect of Echocardiography in Evaluating Right Heart Dysfunction Related to ARDS

**Di Nie, ChunboYang***
*Department of Critical Care Medicine, First Affiliated Hospital of Xinjiang Medical University, Urumqi, China*
**Corresponding Author*

**Abstract: Acute respiratory distress syndrome (ARDS) is a group of respiratory syndromes mainly characterized by acute hypoxic respiratory failure. The chest imaging shows diffuse infiltration shadows in both lungs, which cannot be fully explained by heart failure or fluid overload. During the pathophysiological process of ARDS, it often affects the right heart function of patients and is a predominant cause of death for critically ill patients. Right heart dysfunction related to ARDS significantly increases the risk of death for patients. Therefore, early and accurate identification and dynamic assessment of it are of great significance. Echocardiography, with its advantages of being non-invasive, real-time and operable at the bedside, has become a pivotal tool for accurately assessing right heart insufficiency related to ARDS. This article reviews the current situation of right heart dysfunction related to ARDS evaluated by echocardiography and looks forward to future research directions, with the aim of providing guidance for the monitoring and management of right heart function in ARDS patients.**

**KeyWords: Acute Respiratory Distress Syndrome; Right Heart Insufficiency; Echocardiography; Research Status; Prospect**

Acute respiratory distress syndrome (ARDS) mainly refers to acute diffuse inflammatory lung injury stemmed from the combined action of multiple intrapulmonary and/or extrapulmonary factors. The predominant clinical manifestations include refractory hypoxemia, pulmonary edema, and decreased lung compliance, with a high mortality rate[1-3]. Related research reports indicate that the pathological and physiological processes of ARDS may involve right ventricular function, leading to ARDS-related right heart dysfunction with an incidence rate of 25-50%. It is also an independent risk factor for death in ARDS patients and increases the likelihood of in-hospital mortality[4-6]. At present, echocardiography has become a core tool used in intensive care units (ICUs) to evaluate changes in right heart function in ARDS patients, providing guidance for the development and implementation of subsequent treatment plans[7-8]. This article reviews the relevant research on the application of echocardiography in the assessment of ARDS-related right heart dysfunction, aiming to provide reference for clinical practice and future development directions.

## 1. The Pathophysiological Mechanism of Right Heart Dysfunction Stemmed from ARDS

ARDS is a common critical illness in clinical practice, characterized by acute diffuse lung injury resulted from dysfunction of alveolar epithelial cells and capillary endothelial cells, leading to disruption of the alveolar capillary barrier[9-10]. Normal lung tissue often has a complete respiratory epithelial layer and alveolar space, while the occurrence of ARDS can cause the rupture of the alveolar capillary barrier, leading to the accumulation of a large amount of edema fluid and debris in the alveolar space, while promoting the release of a large number of alveolar macrophages and monocytes, further causing inflammatory reactions and accelerating disease progression, leading to severe pulmonary functional and organic damage, ultimately affecting right heart function, manifested as right heart dysfunction. With the continuous deepening of related research in recent years, more and more scholars have discovered the following

 

phenomena[11-13]. The mechanism of ARDS induced right heart dysfunction may be related to the following aspects: ① Increased pulmonary vascular resistance; ② Elevated right ventricular afterload; ③ Ventricular interdependence; ④ Mechanical ventilation; ⑤ The action of inflammatory factors. The influencing factors of increased pulmonary vascular resistance include hypoxic pulmonary vasoconstriction, mechanical pulmonary microvascular obstruction, and pulmonary vascular remodeling.

## 2. Indicator Support for ARDS Induced Right Heart Dysfunction

Right heart dysfunction is often stemmed from existing or newly developed cardiovascular diseases, or a combination of both, leading to a decrease in right ventricular systolic force and abnormal changes in right ventricular mechanics and function due to pressure and/or volume overload stemmed from the primary disease, resulting in right heart dysfunction. At present, the primary criteria for diagnosing right heart dysfunction in clinical practice include risk factors, symptoms and signs, laboratory indicators, and imaging abnormalities.

### 2.1 Clinical Symptoms

Right heart dysfunction is predominantly stemmed from the combined action of various factors leading to excessive right heart pressure or volume load, resulting in right heart systolic dysfunction. Simultaneously, right heart dysfunction is often secondary to left heart dysfunction or (and) severe lung disease. Therefore, its major symptoms may include paroxysmal nocturnal dyspnea, decreased exercise endurance, fatigue and burnout, and prolonged recovery time of ankle joint swelling after exercise. The primary signs may include a significant increase in jugular vein pressure, positive liver neck reflux sign, and third heart sound. However, the above symptoms and signs are typical manifestations, and in practical work, some patients with right heart dysfunction may still have atypical manifestations. Therefore, clinical diagnosis still needs to be combined with other indicators.

### 2.2 Laboratory Examination

The commonly used laboratory indicators for evaluating right heart dysfunction in clinical practice include B-type natriuretic peptide and N-terminal B-type natriuretic peptide precursor, which are abnormally elevated in patients with right heart dysfunction. The primary mechanism may be that when the right ventricular pressure load increases or expands, it leads to an increase in ventricular wall tension, thereby stimulating the massive secretion of B-type natriuretic peptide. Another research report suggests that multiple serum inflammatory factors are abnormally expressed in patients with right heart dysfunction. For example, tumor necrosis factor-α (TNF-α) can promote cardiomyocyte apoptosis and inhibit myocardial contractility by regulating pathways such as the NF kB pathway;Overexpression of interleukin-6 (IL-6) can promote abnormal activation of the JAK-STAT pathway, leading to myocardial hypertrophy and fibrosis;Interleukin-1 β (IL-1 β). Another research report points out that， inflammatory factors may lead to right heart dysfunction through various pathways such as myocardial injury, ventricular remodeling, and pulmonary vascular disease, and may form a personality cycle with metabolic abnormalities and systemic inflammation.

### 2.3 Imaging Examination

At present, there are many imaging examination methods used for the assessment of right heart dysfunction in clinical practice, which comprise cardiac magnetic resonance imaging, CT examination (including cardiac CT and pulmonary vascular CT), chest X-ray, and nuclear imaging[24-25]. Among them, cardiac magnetic resonance imaging is widely recognized as the gold standard for evaluating right heart dysfunction both domestically and internationally, predominantly manifested as abnormal changes in the structure and function of the right ventricle, such as right ventricular end diastolic volume>110ml/m $^2$ (male) or >100ml/m $^2$ (female), right ventricular enlargement, right ventricular free wall or interventricular septal enhancement. CT examination is predominantly used for etiological diagnosis, among which cardiac CT manifestations include right ventricular enlargement, ventricular septal flattening or left shift, abnormal pulmonary artery dilation, etc; Pulmonary vascular CT findings include

 

pulmonary embolism and chronic thromboembolic pulmonary hypertension. Chest X-ray is primarily an auxiliary examination method, which primarily presents with right ventricular enlargement, pulmonary artery segment protrusion, widened superior vena cava, and pleural effusion. As one of the auxiliary evaluation methods, nuclear imaging principally presents with right ventricular myocardial ischemia and metabolic abnormalities.

## 3. Application of Echocardiography in the Assessment of ARDS-Related Right Heart Dysfunction

As a pivotal tool for evaluating right heart function in clinical practice, echocardiography is featured by minimal trauma, simple operation, and high reproducibility, and has been widely used in the assessment of right heart function. In recent years, with the rapid development of technologies such as three-dimensional ultrasound and strain imaging, echocardiography has made significant progress in the early diagnosis, severity assessment, and prognosis prediction of right heart dysfunction.

Transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) are common clinical methods for evaluating right heart dysfunction. TTE has the advantage of non-invasiveness, principally through chest wall imaging, with high reproducibility, especially suitable for disease screening and follow-up. The commonly used sections include parasternal long/short axis, apical four chamber heart, and inferior xiphoid process section. The relevant evaluation indicators involve the following three aspects: ① Two-dimensional indicators (such as right ventricular area change fraction and tricuspid annular systolic displacement, etc.); ② Doppler indicators (such as tricuspid regurgitation velocity, Tei index, etc.); ③ Organizational Doppler indicators (such as tricuspid annular systolic velocity).

TEE has the characteristics of high resolution and three-dimensional reconstruction, and the probe is closely adjacent to the heart during the examination process, which can display the structure of the patient's right heart in a more clear manner. It is suitable for cardiac surgery or intensive care patients, especially in evaluating artificial valves, thrombosis, and endocarditis, showing unique advantages. The evaluation parameters include right ventricular volume, ejection fraction, and right ventricular response to load changes.

## 4. Conclusions and Prospects

Echocardiography has been widely used in the evaluation of ARDS-related right heart dysfunction, with advantages such as non-invasive, real-time, and bedside operation. This principally includes TTE and TEE. It may play a crucial role in early identification of high-risk patients, guiding clinical treatment, guiding fluid management, and assessing the risk of withdrawal. However, it may still pose certain challenges. The image quality may be affected by factors such as obesity, body position, mechanical ventilation, breathing, heart rate, etc., leading to a decrease in measurement accuracy; There are no specific diagnostic criteria or threshold values for ARDS internationally. The author believes that the future development of the application of echocardiography in the assessment of ARDS-related right heart dysfunction should focus on the following aspects: ① Establishment of standardized operating procedures and norms; ② Continuous efforts to deepen new indicators; ③ Acceleration with regard to the integration of multimodal monitoring; ④ Breakthrough technological bottlenecks with the assistance of artificial intelligence. Through continuous research, innovation, and improvement, echocardiography will further enhance its evaluation value in ARDS-related right heart dysfunction, ultimately providing reliable evidence for individualized critical care management.

## References

[1] Wang Wei, Xiang Boyu, Zhang Qianjiang, Sun Fei. Correlation analysis between serum SIRT1, ESM-1, FGF21 expression levels and treatment outcomes in patients with sepsis associated acute respiratory distress syndrome[J]. Journal of Clinical Medicine in Practice, 2025, 29(3): 46-50,56.

[2] Han Hu, Zhang Litao, Xu Xin. Pathogens, drug resistance, and serum expression of ESM-1, sTREM-1, and MIP-1 α in

 

pulmonary infections caused by acute respiratory distress syndrome[J]. Chinese Journal of Nosocomiology, 2025, 35(5): 647-651.

[3] Yang P, Sjoding MW. Acute Respiratory Distress Syndrome: Definition, Diagnosis, and Routine Management[J]. Crit Care Clin, 2024, 40(2): 309-327.

[4] Lyu Youkai, Ji Xiaoxia, Yun Tianqi. Study on the effect of ultrasound-guided VTI guided fluid resuscitation in the treatment of ARDS with right heart dysfunction[J]. China Journal of Emergeney Resuscitation and Disaster Medicine, 2025, 20(2): 207-211.

[5] Petit M, Jullien E, Vieillard-Baron A. Right Ventricular Function in Acute Respiratory Distress Syndrome: Impact on Outcome, Respiratory Strategy and Use of Veno-Venous Extracorporeal Membrane Oxygenation[J]. Front Physiol, 2022, 14(12): 797252.

[6] Jahngir MU, Nabizadeh-Eraghi P. Use of Right Ventricular Assisted Device for Right Heart Failure in a Patient With Acute Respiratory Distress Syndrome [J]. Cureus, 2021, 13(9): e17671.

[7] Wu Changdong, Hou Ming, Yang Rong, et al. Diagnostic significance of combined detection of two-dimensional echocardiography, BNP, 6MWT, and MMRC for right heart dysfunction in patients with acute exacerbation of chronic obstructive pulmonary disease[J]. Chinese Journal of Lung Diseases (Electronic Edition), 2019,12(4): 441-444.

[8] Wu Changdong, Hou Ming, Yang Rong, et al. Correlation between two-dimensional echocardiography, BNP, 6MWT, and mMRC in evaluating right heart dysfunction in AECOPD patients [J]. Chinese Journal of Clinical Research, 2020, 33(1): 27-30.

[9] Giannakoulas G, Farmakis IT, Hobohm L, et al. Acute right ventricular failure: pathophysiology, aetiology, assessment, and management[J]. Eur Heart J, 2025, 46(26): 2520-2535.

[10] Aqi, Wang Jingchao. Analysis of the predictive value of inflammatory factor levels in bronchoalveolar lavage fluid for the prognosis of patients with moderate to severe acute respiratory distress syndrome[J]. Chinese Journal of Medicine, 2025, 60(3): 305-307.

[11] Pan Xiaodong, Cheng Jinglin. Value of two-dimensional speckle tissue tracking imaging technology in the assessment of right ventricular function in patients with acute respiratory distress syndrome[J]. Doctor, 2023, 8(5): 120-123.

[12] Liu Xuesong, Xu Yonghao, Liu Dongdong, et al. Application of bedside ultrasound in high-risk pulmonary embolism in patients with severe pneumonia[J]. China Medicine and Pharmacy, 2021,11(12): 237-241.

[13] Liu Xuesong, Zhang Rong, Xi Yin, Chen Sibei, Liu Xiaoqing, Li Yimin. Management of right heart dysfunction in severe ARDS patients treated with VV-ECMO[J]. International Journal of Respiration, 2020, 40(12): 904-910.

 