Early View

Invited review

ERS International Congress 2023: highlights from the Pulmonary Vascular Diseases Assembly

Sarah Cullivan, Athénaïs Boucly, Mitja Jevnikar, Benoit Lechartier, Silvia Ulrich, Laurent Bertoletti, Olivier Sitbon, Anton Vonk-Noordegraaf, Leon Genecand, Julien Guiot, Etienne-Marie Jutant, Lucilla Piccari, Mona Lichtblau


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ERS International Congress 2023: highlights from the Pulmonary Vascular Diseases Assembly

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Pulmonary vascular diseases such as pulmonary embolism and pulmonary hypertension are important and frequently under recognized conditions. This article provides an overview of key highlights in pulmonary vascular diseases from the 2023 ERS congress. This includes insights into disease modification in pulmonary arterial hypertension and novel therapies such as sotatercept, and seralutinib. Exciting developments in our understanding of the mechanisms underpinning pulmonary hypertension associated with interstitial lung disease are also explored. A comprehensive overview of the complex relationship between acute pulmonary embolism and chronic thromboembolic pulmonary hypertension (CTEPH) is provided and our current understanding of the molecular determinants of CTEPH. The importance of multidisciplinary and holistic care cannot be understated, and this article also addresses advances beyond medication, with a special focus on exercise training and rehabilitation.
Introduction

Diseases of the pulmonary vasculature contribute considerably to the global burden of chronic respiratory diseases. Pulmonary vascular diseases encompass a spectrum of conditions that are frequently underrecognized, including pulmonary embolism (PE) and pulmonary hypertension (PH). The ERS has made a concerted effort to improve awareness, provide education and facilitate research into this important area\cite{1, 2} and this is reflected in the pulmonary vascular disease track at this year’s conference. We witnessed exciting developments in novel therapies for pulmonary arterial hypertension (PAH) that target the transforming growth factor β and the platelet-derived growth factor receptor pathways. Our understanding of the precise mechanisms underpinning PH associated with interstitial lung disease has improved and there is renewed interest in screening tools, phenotyping, and new therapies for this important group. There are continued advances in the fields of venous thromboembolism and chronic thromboembolic pulmonary disease. The accurate and timely diagnosis of acute PE, appropriate management and early identification of specific complications such as chronic thromboembolic pulmonary hypertension (CTEPH) are important areas that were explored at ERS 2023. The pulmonary vascular diseases community had a prominent role and strong voice at the congress this year and the future appears bright for these important diseases \cite{3}.

Novelties in pulmonary arterial hypertension

The concept of disease modification in PAH was explored at this year’s conference. To meet the definition of a disease modifying treatment it must target the underlying pathophysiology and result in a sustained clinic benefit, which differs from a purely symptomatic benefit. Therefore there should be a clear correlation with clinical outcomes and a disease specific biomarker that can demonstrate this \cite{4}. Five levels of disease modification in PAH were outlined, with level 1 therapies slowing clinical decline and level 5 therapies resulting in a cure, such as lung transplantation. Among new treatments tested for PAH, two seem particularly promising and offer potential disease modifying properties. These include sotatercept targeting the transforming growth factor (TGF) β superfamily pathway, and seralutinib, an inhaled platelet-derived growth factor receptors (PDGFR) inhibitor.

**Sotatercept** is an activin signalling inhibitor, which aims to restore the balance between pro-proliferative and anti-proliferative signalling in PAH. In the phase II PULSAR and phase III STELLAR trials, both conducted in PAH patients with functional class II or III symptoms, sotatercept added to background double or triple combination therapy significantly improved pulmonary vascular resistance (PVR) and exercise capacity assessed by six-minute walk distance (6MWD)\cite{5, 6}. A post-hoc analysis of the STELLAR trial assessed changes in haemodynamics and right ventricular function as assessed by right heart catheterization (RHC) and echocardiography at 24 weeks. Relative to placebo, sotatercept led to significant improvements in haemodynamic parameters including right atrial pressure, mean pulmonary artery pressure (mPAP), mixed venous oxygen saturation, pulmonary artery elastance and compliance, as well as tricuspid annular plane systolic excursion (TAPSE) to systolic pulmonary artery pressure ratio as assessed by echocardiography. However, there were no significant changes in heart rate, cardiac output, cardiac index, stroke volume or stroke volume index or TAPSE. Together with the clinical benefits observed with sotatercept in the STELLAR trial, results of this post-hoc analysis underscore the clinical relevance of improving cardiopulmonary haemodynamics, right heart function and coupling between the pulmonary artery and the right ventricle in these patients \cite{7}.
Seralutinib is a tyrosine kinase inhibitor administered via a dry powder inhaler. Seralutinib inhibits PDGFR, the CSF1R receptor and c-KIT. In addition, seralutinib also leads to an increase in BMPR2, thereby promoting antiproliferative action. The phase 2 TORREY trial met its primary endpoint by demonstrating a significant reduction in the PVR in patients with PAH treated with inhaled seralutinib, on background double or triple combination therapy [8]. A substudy presented at ERS, used thin-section, volumetric non-contrast chest CTs followed by automated pulmonary vascular segmentation to assess seralutinib-induced reverse remodelling of the pulmonary vasculature. Blood vessels volumes were determined at distinct levels defined by vessel cross-sectional area (>5mm² and >10mm²) in 19 subjects on double or triple PAH-specific background therapy at baseline and at 24 weeks. There was a significant improvement in the ratio of blood vessel volume in distal vessels relative to larger vessels, consistent with a reverse remodelling effect of seralutinib. The change in the ratio of blood vessel volume from baseline to week 24 correlated with the change in hemodynamic parameters such as pulmonary artery compliance or stroke volume [9]. A CT substudy is planned for the Phase III PROSERA trial to increase our understanding of the effects of seralutinib on pulmonary vascular remodelling (NCT 05934526). An improved understanding of the role of the PDGF and TGF pathways in the pathobiology of PAH and the development of therapies to inhibit these pathways have raised great hopes for the future management of PAH and would not be possible without basic science. A selection of molecular pathways that were presented at the poster session for basic mechanisms in pulmonary hypertension are outlined below in Table 1.

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Table 1: Outlines some of the molecular pathways that were presented at the poster session for basic mechanisms in pulmonary hypertension at ERS 2023. *Abbreviations: ATP: adenosine triphosphate; CREB: cAMP response element binding protein) PASCM: pulmonary artery smooth muscle cell; RV: right ventricle*

The haemodynamic definition of PH was re-examined at the Sixth World Symposium on PH, and a precapillary pattern of PH is now defined as a mPAP >20 mmHg, a PVR >2 WU and a pulmonary artery wedge pressure ≤15 mmHg [3, 10]. The demographics of PAH are changing, and the clinical phenotype is evolving and this was taken into consideration when constructing the 2022 ESC/ERS guidelines for the diagnosis and management of PH [3, 11]. PAH is frequently identified in older patients, with concomitant comorbidities and current guidelines recommend initial monotherapy for these patients, rather than upfront double combination therapy, as side effects are more common in this cohort and therapeutic gains may be attenuated [3]. Data presented by Boucly *et al* this year, compared the efficacy of initial oral monotherapy and double combination therapy in PAH patients with at least 1 cardiovascular comorbidity (obesity, diabetes, hypertension, coronary heart disease) from the French PH registry [12]. Among 1,088 patients with PAH and at least one comorbidity, 655 received initial monotherapy and 398 double combination therapy. The proportion of patients achieving a low risk or
intermediate-low risk status was higher in patients with initial dual therapy compared to initial monotherapy (53% vs. 45%, p=0.029), with higher functional and hemodynamic improvement, and a trend to better survival at 1 year but without statistical differences in long-term mortality. The tolerability of the two strategies was similar with similar rates of discontinuation. Further data pertaining to this important topic was presented by McLaughlin et al. This was a post-hoc study on the effects of inhaled Treprostinil (iTre) on patients with PAH and ≥1 cardiovascular comorbidity in the pivotal TRIUMPH study [13]. This was a randomized double blind controlled study of iTre in patients with PAH on background therapy, and met its primary endpoint of change in 6MWD. Of the 235 patients in the study, 68 had 1 comorbidity and 56 ≥ 2 comorbidities. Improvement in 6MWD and NT-proBNP were similar in patients treated with iTre compared to placebo, irrespective of the number of comorbidities[14]. These studies suggest that double combination PAH therapy and even triple therapy was well tolerated and effective in patients with PAH and cardiovascular comorbidities and underscores that further research is warranted to address this important topic.

Group 3 pulmonary hypertension

PH associated with lung diseases and/or hypoxia (group 3) is frequently recognized in patients suffering from chronic obstructive pulmonary disease (COPD), emphysema, interstitial lung diseases (ILDs), combined pulmonary fibrosis and emphysema (CPFE) and hypoventilation syndromes [3]. Approximately 5-10% of patients with PH associated with chronic lung diseases (CLD) will develop severe PH, which is defined at RHC as a pulmonary vascular resistance (PVR) greater than 5 WU as per the 2022 ESC/ERS PH guidelines [3]. To date, there are still unmet clinical needs mainly to better define a specific treatment strategy. There is limited and conflicting evidence indicating the use of approved medication for patients with group 3 PH, apart from iTre that has recently proved to be effective in patients with PH associated with ILDs (PH-ILD)[15]. The main baseline treatment strategy for Group 3 PH is the optimization of the underlying lung disease including supplementary oxygen and non-invasive ventilation, where indicated, as well as enrolment into pulmonary rehabilitation program.

PH is commonly observed in patients with ILDs and has significant effects on patient outcome. Pulmonary vascular remodelling in PH-ILD was often viewed as a ‘passive’ process that was limited to regions of fibrotic lung. There has been a paradigm shift in PH-ILD as we now appreciate that pulmonary vascular changes can occur in regions of apparently normal pulmonary parenchyma with no fibrosis. A recent review by Ruffenach et al describes the common and distinct lesional mechanisms observed in ILD patients with or without PH -ILD [16]. In both cohorts, bone morphogenetic protein receptor 2 (BMPR-2) expression and signalling is reduced and altered adenosine signalling is observed. The genetic signature of these cohorts differs, with increased pro-angiogenic gene expression in those with PH-ILD. Furthermore, hypoxia-inducible factor-1 (HIF1) activation and the Slug-prolactin-induced-protein axis are upregulated in PH-ILD, resulting in pro-proliferative and anti-apoptotic signalling[16].

While PH-ILD physiopathological process is induced by specific underlying mechanisms, its occurrence can be challenging to identify in clinics. PH-ILD risks factors are numerous including genetics, epigenetics and environmental factors. [17] Moreover, underlying ILD disease can be associated with an increased risk of PH-ILD as it is recognized in CPFE and lymphangioleiomyomatosis. Screening tools have been developed to identify PH-ILD but require further validation [18, 19]. A modified Delphi consensus published in 2022 highlighted important risk factors, symptoms, signs and investigation results that should prompt consideration of PH in patients with ILD [20]. These include CT features
such as the pulmonary artery to ascending aorta increased ratio, a decline in the diffusion capacity for carbon monoxide (DLCO) of more than 15%, or disproportionate oxygen reduction during exercise compared to ILD extension. The importance of longitudinal follow-up (trends) was emphasized, particularly worsening gas exchange and/or exercise tolerance out of proportion compared to decline in lung volumes. In this context, abnormal clinical changes should prompt further investigation with echocardiography in order to exclude the occurrence of PH-ILD whereas RHC has to be considered in specific subgroups of patients [20].

It is frequently challenging to differentiate PH-CLD from other important causes of PH including IPAH, especially when patients have mild lung disease based on imaging with preserved pulmonary functional tests. New diagnostic tools in order to tackle this question are under development trying to enhance disease quantification and prediction. During ERS conference 2022, Dwivedi et al presented their study exploring the use of artificial intelligence (AI) to improve the quantification and prognostication of lung disease on CT in PH [21]. They developed a novel deep-learning AI model to quantify the percentage of normal lung or lung with abnormalities defined as ground glass, ground glass with reticulation, emphysema, honeycombing and fibrosis. Combining AI with clinical and radiological assessments improved prognostic predictive strength and the authors suggest that this could enhance phenotyping and patient management [21]. In a prospective study of 117 patients with CLD and 38 with IPAH, Garcia et al. performed quantitative assessment of pulmonary vascular volumes using CT, to investigate whether patients with severe PH associated with specific lung conditions had a lower density of pulmonary microvasculature [22]. Interestingly, in this study the severity of PH-CLD unrelated to the extent of the disease assessed through vascular volume.

The role of PH-specific therapies is still unclear and frequently suspected to be deleterious on gas exchange due to the inhibition of hypoxic vasoconstriction despite the identification of specific pathways involving preserved parenchymal lung regions. A systematic review and meta-analysis of the effect of targeted PAH therapies on arterial oxygenation in patients with PH-CLD by Blanco et al has addressed this specific question. This meta-analysis of 11 studies including 872 patients concluded that the use of these targeted therapies in patients with group 3 PH does not appear to impair arterial oxygenation [23].

Due to conflicting evidence, prescribing practices for patients with PH-ILD are heterogeneous and differ despite the absence of approved specific therapies, knowing that multiple trials failed to be effective. In multiple PH-CLD condition (unless in PH-ILD). In a survey of 55 clinicians exploring the management of PH-ILD in Europe, 50% of physicians reported prescribing off-license PH therapies for their patients with PH-ILD [24]. Of these, phosphodiesterase type-5 inhibitors (PDE5i) are generally considered as the 1st line drug in 78% of cases. This underscores the urgent need for evidence-based guidelines and licensed therapies for this group of patients [24]. Recently, inhaled Treprostinil (iTre) was approved for use in patients with PH-ILD by the FDA in 2022 following the INCREASE trial and it is the first licensed drug in this indication [15]. The INCREASE trial was a 16-week randomized placebo-controlled trial evaluating iTre in patients with PH-ILD, which met its primary endpoint of change in 6-minute walk distance (6MWD) [15]. In a post hoc analysis of the open label extension study, a cohort of 36 patients were subsequently initiated on PDE5i [25]. Preliminary data indicates that the addition of PDE5i in a subset of patients with PH-ILD treated with iTre may be safe. The overall field of group 3 PH is large and composed of various diseases. PH-CLD remains to be thoroughly explored in order to clarify the potential benefit of specific vasodilator treatments and to confirm the best strategy for patient management [25].

Pulmonary embolism and CTEPH
This year saw continued advances in the fields of venous thromboembolism (VTE) and chronic thromboembolic pulmonary disease (CTEPD). The accurate and timely diagnosis of acute PE, appropriate management and early identification of specific complications such as CTEPH are important areas that were explored at ERS 2023.

The PE in Patients (PEP) with an Acute Exacerbation of Chronic Obstructive Pulmonary Disease (COPD) study was an important multicentre cross-sectional study that aimed to define the prevalence of PE in patients admitted with COPD and an acute deterioration in respiratory symptoms [26]. This study reported a PE prevalence of 5.9% of this cohort [26]. A post hoc analysis of this study was presented this year, which explores the safety and efficacy of CT-sparing diagnostic strategies for patients admitted with acute exacerbations of COPD. The revised Geneva and Wells PE scores are widely used and validated scores that use fixed d-dimer thresholds. These were compared to CT-sparing strategies such as the ADJUST-PE, YEARS, PEGeD and 4PEPS scores. While the CT-sparing strategies reduced the need for CTPA by 32%, they were associated with a reduced safety profile and increased false negatives [27].

Another important cohort of patients that are at risk of VTE are those with active cancer. The HOME-PE randomized trial explored the use of the Hestia criteria or simplified PESI score to triage patients with acute PE for home treatment and included patients with cancer associated thrombosis (CAT) [28]. The primary outcome of this study was a composite of recurrent VTE, major bleeding and all-cause death within 30-days post randomization. A post-hoc analysis of this study of patients with CAT revealed that active cancer was associated with an increased risk of the primary outcome at 30-days (OR 7.95; 95%CI [1.48-42.82]), however, home treatment was not (OR 1.19, IC 95% [0.15-9.74]). This data suggests that home treatment may be feasible and safe for patients with CAT and a low-risk PE profile [29].

There is immense interest in the identification of biomarkers that could identify patients at increased risk of complications post PE. Troponin and NT-proBNP are readily available cardiac biomarkers that are frequently used to risk stratify patients at the time of acute PE. In a single center retrospective study of 479 patients post-acute PE, a significant rise in one of these biomarkers occurred in 34% (n=163) of patients within 72 hours of acute PE and was associated with a significant increased risk of death. This underscores the utility of serial measurement of these biomarkers in clinical practice [30].

Complications following PE are not uncommon. Post PE syndrome (PPES) is a term that is used to describe the myriad of symptoms that may follow acute PE, including persistent dyspnoea, impaired exercise capacity and decreased health related quality of life [31]. PPES has numerous aetiologies which includes CTEPD. CTEPH is an important and frequently underrecognized complication of acute PE that is estimated to effect 2.7% of PE survivors[32]. It is characterized by persistent, organized thromboembolic material in the pulmonary vasculature and associated PH. Interestingly, not all patients with CTEPH have a history of acute PE and similarly, not all patients with acute PE will develop CTEPH. Furthermore, CTEPH is often misclassified as an acute PE at the time of presentation and careful consideration of clinical, echocardiography and CT features is warranted, as they may reveal features of same [33]. For example, a systolic pulmonary artery pressure >60mmHg on echocardiography at the time of an acute PE and two or more CT features such as organized mural thrombi, arterial bands or webs and a mosaic perfusion pattern is highly indicative of CTEPH [34]. A CTEPH checklist was presented by Prof. Marion Delcroix, chair of the international CTEPH association, which incorporates clinical features, echocardiography, CT parameters and CTEPH risk factors that should be considered at the time of acute PE and again at 3-6 months to ensure that CTEPH cases are
not missed (https://www.uzleuven.be/nl/centrum-pulmonale-hypertensie/checklist-cteph-after-acute-pe). Additionally, a panel of 8 plasma microRNAs that are differentially expressed between CTEPH and PE patients has been identified and could further refine risk predication models if validated in larger cohorts [35].

The molecular determinants of CTEPH have not been fully elucidated. Prof Bogaard provided a stunning overview of the molecular steps that are potentially implicated in the pathobiology of CTEPH. These include haematological factors such as increased clot formation, reduced thrombolysis and impaired clot angiogenesis [36-38]. Infection, inflammation, and endothelial injury may also play an important role in the development of CTEPH. Neutrophil extracellular traps have been observed in plasma samples from patients with CTEPH, which may lead to increased platelet aggregation [37]. Increased endothelial expression of von Willebrand (vW) Factor has also been demonstrated in patients with CTEPH, and results in increased in vitro platelet aggregation [38]. This has been linked to an inflammatory change in NFkB and an epigenetic change to the vW promoter region [38]. Altered TGF beta signaling may contribute to impaired fibrinolysis, as thrombus removal is impaired with increased levels of same [36]. Pulmonary endarterectomy (PEA) material from patients with CTEPH demonstrate an inflammatory profile that may also have a role in disease progression [39]. While numerous molecular abnormalities have been described in CTEPH, the precise temporal relationship of these mechanisms is not precisely understood and requires ongoing exploration.

Vascular lesions in CTEPH are typically divided into proximal and distal disease. The former referring to proximal organized fibrous material in large pulmonary arteries, and the latter describing a secondary microvasculopathy of smaller pulmonary vessels [34]. All CTEPH cases should be discussed at a CTEPH MDT to define the distribution of disease and to guide treatment decisions. Current therapies include anticoagulation, PH specific therapies, balloon pulmonary angioplasty (BPA) and PEA [34]. Many patients will receive a combination of these therapies termed multimodal therapy and while we do not currently have randomized controlled trials comparing BPA and PEA, these studies are underway.

Lifelong anticoagulation is recommended for patients with CTEPH. Preliminary results from the HEMA-HTP study (NCT02800941) were presented this year. This multicenter prospective study explores the frequency of major bleeding in patients prescribed oral anticoagulation therapy for CTEPH and PAH. Of the 203 patients included in the study, 23 experienced moderate bleeds and 2 fatal bleeds were reported, highlighting the risk of major bleeding associated with anticoagulation use which should not be underestimated [40]. PH therapies that are currently licensed for use in CTEPH included Riociguat and Treprostinil. The CTREPH study was a 24-week, randomized, double-blind controlled trial, of subcutaneous Treprostinil in patients with inoperable CTEPH or persistent CTEPH post PEA [41]. This study demonstrated that treatment with subcutaneous treprostinil was safe in severe CTEPH and a long-term extension of this study revealed that both high- and low-doses of Treprostinil were efficacious [42]. BPA is an effective treatment for patients with distal CTEPH or patients who are not candidates for surgery for other reasons. It is a safe and effective treatment, particularly in centers, which have accumulated experience. For patients with inoperable CTEPH and a PVR > 4 WU, treatment with Riociguat for 6 months prior to BPA can lower the risk of BPA related complications [43].

PEA is a potential curative surgery for patients with proximal CTEPH, which has a reliable risk profile in experienced centers. The choice of BPA versus PEA depends on the distribution of disease and individual patient characteristics including comorbidities. Individualized risk assessment should be performed for all patients who are under consideration for PEA. A study by Dr Buncclark et al presented this year highlighted the utility of machine learning tools to enhance preoperative risk assessment in patients undergoing PEA. This study identified factors that influence 90-day mortality, 5-year mortality and patient reported outcomes post PEA. For example, important non-invasive variables that
influenced 90-day mortality included age, 6MWD and CAMPHOR parameters [44]. Such tools could enhance individualized risk assessment and associated clinical decisions [44]. The importance of pre-operative assessment of left ventricular (LV) function was also emphasized [45]. In a study of 1266 adult patients who underwent PEA between 2007 and 2018, 135 patients had an elevated post-operative PAWP. Interestingly, 60% of these patients had a normal preoperative PAWP and none of these patients had a prior history of HFpEF. This cohort had significantly lower postoperative gains, including pulmonary haemodynamics, 6MWD, NT-proBNP and patient reported outcomes, and impaired long-term survival. Left atrial volume and LV mass were associated with an elevated postoperative PAWP, emphasizing the importance of preoperative echocardiography and cMRI to identify these patients [45].

The choice of BPA versus PEA can become more complex when patients have sub-segmental disease that may be anatomically suitable for both procedures. In recent surgical reports from leading CTEPH centers, the efficacy of surgery for patients with sub-segmental disease has been shown [46]. A surgical classification was described by The University of California, San Diego, to improve the description of disease within the pulmonary vasculature. This divides surgical CTEPH into proximal (level I and II) and distal (level III and IV) levels [47]. Meanwhile, these lesions can also be effectively treated by BPA, as demonstrated by registry data from expert centers [48]. This emphasizes the important of the CTEPH MDT to review these complex cases and make these individualized, nuanced decisions regarding the optimum treatment approach.

It is currently unknown if CTEPH is a preventable complication of PE. The PEITHO (Pulmonary Embolism Thrombolysis) trial was a randomized comparison of thrombolysis with tenecteplase versus placebo for patients with intermediate high-risk PE. Long-term follow up showed no significant difference in the incidence of CTEPH in the tenecteplase arm [49]. There is immense interest in the role of endovascular therapies such as endovascular thrombolysis and clot extraction and studies such as the HI-PEITHO (NCT04790370) study may address this question. The aim of the above therapies for CTEPH including PH medication, BPA and PEA are to improve haemodynamics and therefore impact patients outcomes. The natural history of CTEPH is closely tied to haemodynamic parameters as a mPAP >30mmHg is associated with a 5-year survival of less than 50%, which falls further to less than 10% when the mPAP is greater than 50mmHg [50].

**Beyond medication**

Exercise is an essential component of holistic care and is safe and efficacious in patients with stable PH [51]. Exercise is associated with numerous benefits including improved quality of life, enhanced exercise capacity and a potential improvement in pulmonary haemodynamics [51]. Perceived barriers to exercise and innovative ways to overcome these were addressed at the conference this year [52, 53]. McCormack et al performed a qualitative exploration of the acceptability and utility of a PH and home-based (PHAHB) physical activity intervention [53]. The convenience and accessibility of an exercise program, improvement of self-regulation skills, accountability and support were identified as important themes. A fully remote exercise PHAHB program was considered highly acceptable among patients with PH as it facilitated exercise in a familiar setting, at a convenient time and removed the burden of travel [53]. These results should influence the design of future bespoke PH exercise programs.
Dyspnoea in patients with PH is multifactorial, and there is immense interest in the exploration of novel methods to address this and to enrich rehabilitation programs. Vieira et al performed a randomized double-blind control trial to evaluate the impact of inspiratory muscle training (IMT) on patients with PAH and CTEPH. Thirteen patients with PH were randomized to IMT, which comprised of 30 breaths of training with 50% of maximal inspiratory pressure, twice a day for 8 weeks. Thirteen patients were randomized to the control group, who trained against 5cm of water resistance. This study showed a significantly improvement in 6MWD and reduced dyspnoea in patients who underwent IMT, suggesting that IMT could be an interesting add-on to existing respiratory rehabilitation if these results are confirmed in larger studies [54]. A pilot study of a digital 1-Minute Walk Test (1MWT) as a novel decentralized endpoint in PH research was presented by Newman et al. This study revealed that the 1MWT significantly correlated with the 6MWT and enhanced remote patient evaluation [55]. It had technical accuracy, construct validity and was acceptable to patients.

Conclusion

The ERS 2023 congress provided a wonderful opportunity to network, reconnect with colleagues, and discuss the latest research in pulmonary vascular diseases with experts in the field. Emerging therapies such as sotatercept and seralutinib and novel insights into important groups such as PH-ILD and CTEPH have provided much food for thought. The publication of the 2022 ESC/ERS guidelines for the diagnosis and treatment of pulmonary hypertension has provided a road map for future developments in the field and this is reflected in the numerous developments that were presented this year. The importance of sharing valuable research and education with colleagues from around the globe cannot be understated and underpin the very heart of such meetings.

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