ERS International Congress 2020: highlights from the Clinical Techniques, Imaging and Endoscopy assembly

Pia Iben Pietersen[1,2], Bibi Klap[3], Nicole Hersch[4], Christian B. Laursen[1,5], Simon Walsh[6], Jouke Annema[3] and Daniela Gompelmann[7,8]

Affiliations: [1]Dept of Respiratory Medicine, Odense University Hospital, Odense, Denmark. [2]Regional Center for Technical Simulation, Region of Southern Denmark, Odense, Denmark. [3]Dept of Respiratory Medicine, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands. [4]Dept of Respiratory Medicine, St George Hospital, Sydney, Australia. [5]Dept of Clinical Research, Faculty of Health Sciences, University of Southern Denmark, Odense, Denmark. [6]National Heart and Lung Institute, Imperial College, London, UK. [7]Dept of Internal Medicine II, Division of Pulmonology, Medical University of Vienna, Vienna, Austria. [8]Division of Thoracic Surgery, Medial University of Vienna, Vienna, Austria.

Correspondence: Daniela Gompelmann, Dept of Internal Medicine II, Division of Pulmonology, Medical University of Vienna, Währinger Gürtel 18–20, 1090 Vienna, Austria.
E-mail: daniela.gompelmann@directbox.com

ABSTRACT The European Respiratory Society congress in the year 2020, a year dominated by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic, was the first virtual congress planned with an innovative and interactive congress programme upfront. It was a large, novel platform for scientific discussion and presentations of cutting-edge innovative developments. This article summarises a selection of the scientific highlights from the Clinical Techniques, Imaging and Endoscopy assembly (assembly 14). In addition to presentations on the important role of bronchoscopy, imaging and ultrasound techniques in the field of SARS-CoV-2 infection, novel diagnostic approaches and innovative therapeutic strategies in patients with lung cancer, interstitial lung disease, obstructive airway disorders and infectious diseases were discussed.

@ERSpublications
A summary of developments in interventional pulmonology, imaging techniques and ultrasound presented at #ERSCongress2020. Novel diagnostic and therapeutic approaches in various lung diseases are discussed. https://bit.ly/2Q2aX84

Cite this article as: Pietersen PI, Klap B, Hersch N, *et al.* ERS International Congress 2020: highlights from the Clinical Techniques, Imaging and Endoscopy assembly. *ERJ Open Res* 2021; 7: 00118-2021 [https://doi.org/10.1183/23120541.00118-2021].

Received: 17 Feb 2021 | Accepted: 27 March 2021

Introduction

Key topics at the first virtual European Respiratory Society (ERS) International Congress (2020) included novel diagnostic and therapeutic approaches in patients with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, lung cancer, interstitial lung disease, obstructive airway disorders and infectious diseases. Authors from the different assembly 14 subgroups focus on the key take-home messages, given new study results, and place them in the context of the current knowledge in these areas.

Group 14.01: interventional pulmonology

COPD

Targeted lung denervation (TLD) is a novel endoscopic treatment for patients with symptomatic COPD, which aims to disrupt the parasympathetic nerves around the main bronchi by radiofrequency ablation [1].

At the ERS congress in 2018, Slebos *et al.* [2] presented data from a randomised sham-controlled double-blinded multicentre trial showing the feasibility and safety of this treatment in patients with moderate-to-severe COPD. In 2019, the AIRFLOW-2 study group published an article in which the safety of TLD was prospectively evaluated, with the effect on respiratory adverse events as the primary outcome. The risk of COPD exacerbation requiring hospitalisation in the 12.5-month follow-up was significantly lower in the TLD group than in the sham group [3]. At ERS 2020, Shah *et al.* [4] presented the AIRFLOW-2 crossover patient outcomes, whereby, following the 12-month follow-up visit, patients in the sham group were also offered TLD treatment (crossover group). Acute COPD exacerbations (AECOPD) and lung function were then analysed in these 20 crossover patients. 15 patients had completed 12-month follow-up. The percentage of patients with a moderate or severe AECOPD and severe AECOPD alone following TLD decreased from 73% to 47% and 25% to 13%, respectively. Time to first event for moderate or severe AECOPD and severe AECOPD was also attenuated by TLD.

Frequent COPD exacerbations lead to a more rapid decline in lung function. As TLD reduces the number and severity of COPD exacerbations, Hartman *et al.* [5] studied the annual decline in forced expiratory volume in 1 s (FEV_1) before and up to 3 years after TLD. In 14 patients treated with TLD, the annual decline in FEV_1 was significantly less compared to before treatment (mean FEV_1 decline 1 year before treatment −57 mL per year (n=11) *versus* mean FEV_1 decline 3 years after treatment −24 mL per year (n=14)). The large clinical trial including a control group with 5-year follow-up (AIRFLOW-3), currently underway, will be needed to confirm these results.

A different treatment modality for COPD is endoscopic lung volume reduction (ELVR) with endobronchial valves. Previous studies have shown good clinical outcomes in selected COPD patients so that valve treatment is recommended as additional therapy in patients with advanced emphysema in the Global Initiative for Chronic Obstructive Lung Disease recommendation [6]. Due to a high post-operative mortality rate reported in an earlier surgical trial [7] in the high-risk COPD group, patients with a transfer factor of the lung for carbon monoxide (T_{LCO}) of <20% have usually been excluded from ELVR trials. Lenga *et al.* [8] presented outcomes (lung function, quality of life and exercise capacity) in relation to the T_{LCO} of patients treated with ELVR. 34 patients with a T_{LCO} <20% and 87 patients with a T_{LCO} >20% were included. They found a significant improvement in clinical outcomes 3 months after ELVR in patients with a low T_{LCO}. These data indicate that the treatment response after ELVR might be also beneficial for patients with a low T_{LCO}.

Severity of hyperinflation is one of the key factors for success of ELVR with valves. Prior multicentre randomised controlled trials (RCT) excluded patients with a residual volume (RV) ⩽175%. Klooster *et al.* [9] included 12 patients in a single-centre retrospective study with an RV ⩽175% and a clear target lobe. Lung function (FEV_1, RV), 6-min walk test (6MWT) and St George's Respiratory Questionnaire (SGRQ) improved at both 1 and 6 months after ELVR.

A systematic comparison of surgical lung volume reduction (LVRS) and ELVR with valves is still missing. The Lung Emphysema Registry, a multicentre nonrandomised prospective clinical study, collected data on patients with emphysema treated with LVRS or ELVR [10]. Since 2017, 246 patients have been recruited; the surgical group (n=88) and the ELVR group (n=158) both showed significant improvements in lung function and quality of life at 3 months. Both techniques seem to be beneficial to patients with severe emphysema. A multicentre RCT (the CELEB trial) is underway, which compares the outcomes at 1 year between LVRS and ELVR. Hopefully, this RCT and future studies, including safety data, might help to define which patient subgroups should be treated with LVRS or ELVR.

Chronic hypercapnic failure (CHF) may develop in patients with severe emphysema and hyperinflation. Previous analysis showed improvement in lung function as well as hypercapnia in patients treated with ELVR by coil implantation [11]. In a retrospective trial presented at ERS 2020, 138 emphysema patients with CHF (carbon dioxide tension (P_{CO_2}) ⩾45 mmHg) and treated with ELVR were enrolled. A significant decrease in mean P_{CO_2} (pre-ELVR mean P_{CO_2} 49.8±4.8 mmHg) could be found at 3 months (mean P_{CO_2} 46.1±12.1 mmHg; p<0.001) and 6 months (P_{CO_2} 46.4±18.9 mmHg; p<0.001) after intervention [12]. Prospective trials are warranted.

Take-home messages

- TLD is a safe and effective endoscopic procedure which leads to a significantly lower risk of COPD exacerbation
- After TLD, the annual decline in FEV_1 is significantly less compared to before treatment
- ELVR with endobronchial valves might be beneficial for patients with a T_{LCO} <20%, and also for patients with less severe hyperinflation (RV <175%) in cases with a clear target lobe

Lung cancer

One of the biggest bronchoscopic challenges is how to diagnose small peripheral pulmonary nodules (PPN). The number of patients with PPN that require tissue confirmation is rapidly increasing with the use of computerised chest tomography (CT) and the implementation of lung cancer screening programmes. At ERS 2020, different methods for diagnosing PPN were presented.

Transbronchial lung cryobiopsy (TBLC) is an endoscopic procedure that has proven diagnostic value for interstitial lung diseases [13]; however, there are limited data investigating its use in suspected lung cancer. An observational, retrospective cohort study between 2015 and 2019 enrolled 512 patients who underwent TBLC for suspected lung cancer. The overall diagnostic yield was 93%. 442 cases were malignant and 70 had a nonmalignant pathology with clinical and radiographic follow-up [14]. The complication rate for pneumothorax was 6.6% and for any grade of bleeding was 18%. In most procedures, fluoroscopy and radial endobronchial ultrasound (EBUS) was used for navigation.

These results were confirmed by another observational study evaluating diagnostic efficacy of radial EBUS-guided TBLC of PPN in obtaining histological diagnosis and molecular subtyping [15]. Histopathology was conclusive in 41 (93%) out of 44 patients. Molecular subtyping was performed in 60% (nine out of 15) of squamous cell carcinoma cases and in 88% (15 out of 23) of adenocarcinoma and not-otherwise-specified lung cancer cases.

A late-breaking abstract at ERS 2020 evaluated the efficacy and safety of TBLC and transbronchial forceps biopsy (TBFB) in the diagnosis of PPN [16]. 39 patients were enrolled, with TBFB performed in all patients (n=39) and TBLC performed in addition in 14 patients. Radial EBUS and fluoroscopy was used for guidance with the probe position within the PPN in 33.3% of cases, and adjacent to the PPN in 66.7% of cases. Diagnostic yield of TBFB, TBLC and a combined approach (TBFB+TBLC) were 64.1% (25 out of 39), 64.3% (nine out of 14) and 69.2% (27 out of 39), respectively (p<0.05). The diagnostic yield was 85% (11 out of 13) when placing the radial EBUS probe inside the PPN. No complications occurred.

These studies show that TBLC use in PPN cases results in high diagnostic yields with an acceptable complication profile, especially when used in combination with radial EBUS. However, the added value of TBLC should be evaluated in further randomised trials.

Virtual bronchoscopy navigation (VBN) is a diagnostic modality used to access and sample PPN under fused fluoroscopic guidance. A study from Herth *et al.* [17] included 116 patients with solitary pulmonary nodules ⩾8 mm and compared the biopsy yield and performance of VBN with or without radial EBUS guidance. Overall, biopsy yield was 94% and there was no difference in yield when radial EBUS was used.

Another new innovative technique to diagnose PPN is needle-based confocal laser endomicroscopy (nCLE) which enables real-time microscopic analysis at the needle tip. A study presented at ERS 2020 included 15 patients in whom the feasibility and safety of nCLE imaging for diagnosis of PPN was assessed. In 87% of patients (13 out of 15), good- to high-quality videos were obtained. All malignant lesions scored at least two out of three malignant CLE criteria [18].

EBUS combined with strain elastography might be a helpful diagnostic modality to differentiate malignant lymph nodes [19] by measuring stiffness of a lymph node with ultrasound, where the stiffer node (colouring blue) is more likely to have malignant infiltration. Teng *et al.* [20] presented a prospective study which included 47 patients in whom all lymph nodes >5 mm were sampled and evaluated with elastography. 30 lymph nodes were scored as non-blue, of which final cytology showed only one malignant case. 51 lymph nodes scored mixed blue/green or blue on elastography and cytology showed malignancy in 26 cases. This resulted in a 96% sensitivity rate, but 54% specificity in predicting malignancy, with a negative predictive value of 97%.

Malignant central airway obstruction occurs in ∼20% of primary lung carcinomas or pulmonary metastasis [21, 22]. A novel modality using microwave ablation (MWA) to treat malignant airway obstruction was presented at ERS 2020. MWA heats tissue by creating an electromagnetic field around an ablation device. In five cases successful airway recanalisation was achieved with no immediate complications noted [23]. In addition, MWA offers the potential for local therapy in inoperable peripheral lung cancer and for patients who cannot undergo stereotactic radiation [24]. A pilot study in 13 patients showed that bronchoscopic MWA is a feasible, efficacious and safe treatment for peripheral lung cancer (ineligible for surgery) [25]. The local control rate was 85.71% (12 out of 14) and the complete ablation rate was 78.57% (11 out of 14) at 6 months post-ablation.

Another diagnostic challenge can be the assessment of tumour invasion (T-status) in the mediastinum and large vessels (T4). A retrospective study included 104 patients in whom T-status was reviewed based on EBUS, CT and thoracotomy findings [26]. Surgical–pathological staging was the gold standard, with 36 (27.6%) patients diagnosed as stage pT4. EBUS showed a high specificity (84–98%) and negative predictive value (76–88%) for T4 assessment and could be of additional value to CT alone.

Take-home messages

- TBLC use in suspected lung cancer cases resulted in high diagnostic yields with an acceptable complication profile, especially when radial EBUS is within the PPN
- Bronchoscopic nCLE imaging of PPN is feasible and safe and has the potential to serve as a real-time guidance tool to improve lung cancer diagnostics
- Bronchoscopic MWA is a novel modality, which in case series seems feasible, efficacious and safe for the treatment of peripheral lung cancer and central airway obstruction
- In patients with lung tumours located adjacent to or near the major airways, T4 assessment using EBUS can be of added value

Interstitial lung disease

In interstitial lung disease (ILD), TBLC was a hot topic at ERS 2020. TBLC is a safe alternative to surgical biopsy as shown in the COLDICE trial [27] published in 2020.

One study evaluated safety in 480 patients who underwent TBLC for ILD [28]. Overall, 5.6% developed pneumothorax and 15.8% required a haemostatic agent for bleeding. Patients with antiplatelet or anticoagulant therapy or patients with emphysema had a tendency to develop pneumothorax ($p<0.001$ and $p=0.029$, respectively). The presence of emphysema as a risk factor for pneumothorax following TBLC is comprehensible due to the increased vulnerability of emphysematous lung tissue. However, the antiplatelet drug treatment and its association with the advent of pneumothorax is questionable. It may be explained by the fact that TBLC in patients with anticoagulant therapy is performed intentionally closer to the pleura to avoid the risk of bleeding following central TBLC. The safety of TBLC was again confirmed by Daniels *et al.* [29], who showed an overall pneumothorax rate of 15.1% in 93 patients (mean number of biopsies 3.8±1.3) over a 5-year period. Notably, the annual rate of pneumothorax declined from 29% in 2015 to 8% in 2018 and 2019, emphasising the learning curve.

The impact of various comorbidities on the safety and complications of TBLC are uncertain. In a prospective study of 196 patients with comorbidities including hypertension, diabetes mellitus, ischaemic heart disease, chronic kidney disease and chronic liver disease, none of the comorbidities, alone or in combination, had a significant impact on rates of pneumothorax or bleeding [30].

Tomassetti *et al.* [31] investigated whether the histological information obtained by lung biopsy (surgical or TBLC) had an impact on clinician management in 426 patients without a definite usual interstitial pneumonia pattern. Within this trial, a multidisciplinary team made a management decision before and after lung biopsy. The results showed changes in clinical management in 147 (35%) out of 426 cases. The most notable differences observed were a decrease in both the prevalence of untreated patients (from 15% to 4%; $p<0.001$) and in patients that would have been treated with steroids (from 54% to 37%; $p<0.001$). Antifibrotic and immunosuppressant use increased significantly after lung biopsy revision (from 23% to 44% and from 7% to 14%; both $p<0.001$). In uncertain ILD cases, lung biopsy can be of great value.

Take-home messages

- TBLC is a safe alternative to surgical biopsy in patients with multiple comorbidities
- In uncertain ILD cases, lung biopsy led to a change in treatment in 30% of cases

Group 14.02: imaging

Interstitial lung disease

It is crucial to diagnose ILD at an early stage so that treatment can be started in time. Lung function and chest radiography are the first steps if lung disease is suspected. However, early ILD can be missed on chest radiograph examination alone. At ERS 2020, one study presented data from artificial intelligence (AI) software used to help physicians detect ILDs [32]. The area under the receiver operating characteristics curve (AUROC) for the detection capability of AI was 0.979, with a sensitivity and specificity of 90% and 100%, respectively, exceeding that of human physicians alone. Thus, this software may help to identify patients with ILD at a very early stage, providing an early start of further diagnostics and adequate treatment. However, further research is warranted.

Furthermore, the impact of magnetic resonance imaging (MRI) as an imaging method to assess ILD was explored. One trial examined the usefulness of oxygen-enhanced MRI as a novel biomarker in patients with different ILD phenotypes [33]. As biomarkers, baseline T1, change in delta oxygen tension (ΔP_{O_2}), oxygen wash-in time and ventilated volume fraction were obtained at three different time points and compared with lung function tests. In the subgroup of patients with idiopathic pulmonary fibrosis (IPF), T1 correlated with the diffusion capacity and the change in ΔP_{O_2} between the different visits correlated with the change in the transfer coefficient of the lung for carbon monoxide. These positive correlations could only be observed in the IPF subgroup, but not in the other ILD subtypes.

The utility of 129-xenon (^{129}Xe) diffusion imaging in ILDs is still not well understood. The apparent diffusion coefficient (ADC) and the mean diffusive length scale (Lm_D) is a diffusion-weighted MRI measurement that provides information about lung microstructure down to the alveolar level. In one prospective observational study, three-dimensional diffusion-weighted MRI with hyperpolarised ^{129}Xe was performed twice in 14 patients with IPF [34]. There was a significant longitudinal change in mean ^{129}Xe Lm_D in the lower and middle lung zones, but no significant change in ADC or lung function parameters. Thus, ^{129}Xe Lm_D may be a useful imaging biomarker to assess disease progression and can provide further insight into the lung microstructure in IPF.

Take-home messages

- Artificial intelligence using conventional chest radiographs may help to identify patients with ILD at an early stage
- Oxygen-enhanced MRI and diffusion-weighted MRI may present useful biomarkers that assist in identifying ILD subtype and assessing ILD progression

Lung cancer

Various RCTs, including the Nederlands-Leuvens Longkanker Screenings Onderzoek (NELSON) trial [35] and the National Lung Screening trial (NLST) [36] have demonstrated CT-based lung cancer screening to be efficacious in reducing lung cancer mortality. However, there are still some uncertainties leading to slow initiation of formalised lung cancer screening programmes. So far, recruitment for screening is based on the inclusion criteria of the lung cancer screening trials. One trial presented at ERS 2020 calculated the proportion of lung cancer patients who would have been eligible for lung cancer screening under major trial inclusion criteria [37]. The authors found that only one out of three lung cancer patients would have been invited for screening according to NLST and NELSON criteria. This finding reinforces that additional tools to stratify risk and facilitate earlier diagnosis are needed.

Cui *et al.* [38] evaluated the diagnostic accuracy of a deep-learning based computer-aided detection (DL-CAD) system. In this trial, 360 CT scans were evaluated retrospectively by the DL-CAD system and then independently by radiologists in a double-reading fashion. An additional senior radiologist checked all the results and made the consensus as to the reference standard. The DL-CAD system achieved a sensitivity of 89.3% with one false positive per scan, while radiologists had a sensitivity of 76.0% for detection during double reading. Thus, the DL-CAD system may assist radiologists in pulmonary nodule detection.

Take-home message

- Deep-learning based computer-aided detection system may assist in detecting pulmonary nodules

COPD

In recent years, radiological assessment in patients with COPD has gained importance, particularly in patient selection for ELVR. CT reflects disease severity, emphysema type and distribution.

One trial presented at the congress shows that CT assessment of erector spinae muscle (ESM) may predict long-term mortality of COPD patients [39]. In this prospective observational study, reduction in the cross-sectional area (CSA) of ESM, total airway count, wall area percentage of the segmental airways and airway tree to lung volume ratio were assessed in 247 COPD patients. Reduced ESM_{CSA} was associated with poor prognosis more strongly than the other CT parameters. This finding emphasises the impact of muscle loss on survival of COPD patients and confirms the importance of preventive strategies.

Functional respiratory imaging (FRI) is another CT tool, which provides an assessment of ventilation/perfusion mismatch in COPD patients [40]. Here, quantitative CT measures of lobe expansion and blood vessel volumes are obtained to evaluate ventilation/perfusion values. A pooled cohort of 96 patients were studied retrospectively and the FRI results correlated with clinical outcomes. It was shown that ventilation/perfusion levels correlated significantly with SGRQ, 6MWT and oxygen desaturation during 6MWT. This finding emphasises the impact of ventilation/perfusion mismatch on clinical performance of COPD patients and underlines the importance of restoring the ventilation/perfusion level to improve patients' clinical status.

Take-home messages

- CT assessment of erector spinae muscle loss in COPD patients predicts long-term mortality in COPD patients
- Functional respiratory imaging allows the assessment of ventilation/perfusion mismatch which correlates with COPD patients' clinical status

COVID-19

Coronavirus disease 2019 (COVID-19), caused by SARS-CoV-2, dominated 2020. Infections with SARS-CoV-2 were widespread all over the world leading to a global COVID-19 public health emergency. Besides clinical features and laboratory tests, radiological assessment plays an important role in COVID-19 detection, assessment of disease severity and disease monitoring. In particular, CT reveals the typical COVID-19 features of ground-glass opacities, consolidation and a reticular and/or crazy-paving pattern [41]. Zerka *et al.* [42] evaluated the development of a new AI software to detect COVID-19 patients. This software was shown to have accuracy of 85%, sensitivity of 70%, specificity of 92%, negative predictive value of 95% and positive predictive value of 59%. Thus, this AI software seems to provide an accurate means of detecting COVID-19 patients allowing rapid, accurate diagnosis and facilitating the implementation of isolation procedures and early intervention.

Limitations of CT may include patient transport, machine preparation and scanning time, such that chest radiography, which is more widely available, still plays an important role. However, as chest radiographs are nonspecific and often difficult to interpret, a machine-learned early-detection system using conventional chest radiography to identify COVID-19 and differentiate its phenotypes was evaluated [43]. The sensitivity, positive predicted value and negative predictive value of the machine early-detection system for COVID-19 was 91%, 97% and 99%, respectively, resulting in a diagnostic accuracy of 95%. This encouraging result demonstrates that a machine-learned early-detection system using conventional chest radiography can identify unique features of COVID-19, facilitating fast diagnosis.

Another trial evaluated the impact of chest radiography as predictor of prognosis in COVID-19 [44]. Chest radiographs in 595 patients with symptoms suggestive of COVID-19 were retrospectively analysed and correlated with intensive care unit (ICU) admission, continuous positive airway pressure (CPAP) use, swab positivity and mortality. It showed that in those with COVID-19, a normal chest radiograph was a statistically significant negative predictor of ICU admission, CPAP use, mortality and swab positivity ($p<0.05$).

Take-home messages

- Artificial intelligence software using CT scans or chest radiographs provides identification of COVID-19 patients
- A normal chest radiograph in COVID-19 patients admitted to hospital seems to be associated with a reduced risk of mortality

Group 14.03: ultrasound

COVID-19

The SARS-CoV-2 pandemic has changed the need for rapid evaluation and bedside imaging assessment in order to narrow differential diagnoses without compromising patient and healthcare worker safety, and to limit potential spread of the virus. Due to the increased number of patients in need of supportive care and thereby limited resources, it is of great importance to be able to stratify patients who will experience more mild or severe disease.

Thoracic ultrasound was explored as a tool for predicting severity and clinical outcomes in COVID-19 patients [45]. The authors used a 0–36-point system (12 scanning zones); at a cut-off score of 24 points, they found a sensitivity of 100% and specificity of 69.2%, and AUROC was 0.846 for identifying patients with a worse prognosis (defined as ICU admission or death within 14 days).

The sonographic findings interpreted as COVID-19 were few B-lines (1 point), multiple B-lines (2 points) or consolidation (3 points). No studies have explored this to date, but the prediction by the experienced ultrasound operators in the ERS assembly is that a high correlation is likely. More studies are expected to be published in this area over the next year, leading to a more solid and comprehensive pool of data at ERS 2021.

Take-home messages

- Ultrasonography may be used to assess lung involvement in COVID-19 patients
- The evidence for the use of ultrasound as a screening tool for persistent post-COVID-19 parenchymal abnormalities is sparse

Suspected malignant lung lesions and malignant pleural effusion

The evidence for lung cancer screening programmes is increasing [46]. Without doubt, more clinical studies and potential implementation of nation-based screening programmes will lead to a higher number of interventional procedures in the diagnostic work-up of pulmonary nodules. Transthoracic ultrasound-guided biopsies have gained attention because of fewer complications compared to, for example, CT-guided transthoracic biopsies of peripheral and subpleural lesions.

Sharshar *et al.* [47] presented a study exploring the diagnostic yield and complication rate of ultrasound-guided transthoracic needle biopsies. The results, showing a diagnostic yield of 80% and complication rate of 6.66% for pneumothorax and 3.33% for pulmonary haemorrhage, are supported by a systematic review and meta-analysis of the same topic [48].

Noninvasive methods for the investigation of lung nodules are warranted, especially in patients with comorbidities or reduced lung function. Transthoracic shear-wave elastography has been explored, but so far it is not able to distinguish between benign and malignant lung nodules nor between different histological types of lung cancer [49]. It may be influenced by conditions such as fibrosis, necrosis, air in the surrounding lung parenchyma and pleural effusion.

Ultrasound has a high diagnostic accuracy for the detection of pleural effusion [50]. The presence of pleural effusion most often leads to a cytological examination to rule in or rule out malignancy, but first cytological evaluation implies a sensitivity of only 60% [51]. A systematic review and meta-analysis investigated whether thoracic ultrasound can identify and rule-in malignant pleural effusion (MPE) [52]. The ultrasound findings were not useful in the diagnostic work-up of suspected MPE; however, pleural nodularity in conjunction with pleural effusion could be used as a rule-in test for proceeding with repeated thoracocentesis or additional invasive procedures when malignant disease is suspected.

A systematic review of the current clinical application of contrast-enhanced thoracic ultrasound revealed that its use to guide transthoracic biopsies could increase diagnostic accuracy by 14.6% on average [53]. However, the use of contrast-enhanced ultrasound to distinguish between benign or malignant lesions is not yet well supported by evidence, as overall the studies were heterogeneous, small and with high risk of bias. This reinforces the need for larger, controlled studies before the true application of contrast-enhanced ultrasound can be assessed.

Take-home messages

- Ultrasound-guided transthoracic biopsy of peripheral lesions is feasible and has a high diagnostic accuracy and an acceptable complication rate
- In patients with suspected malignant pleural effusion, ultrasound findings of pleural nodularity warrant further invasive procedures
- More studies on advanced ultrasound modalities (*e.g.* contrast-enhanced thoracic ultrasound, elastography) are needed to determine their role in the work-up of pulmonary lesions

Diaphragm

The amount of literature investigating the sonographic assessment of respiratory musculature has exploded within the past 2 years, with the most commonly evaluated muscle being the diaphragm [54]. The most frequent outcome measures for diaphragmatic function were diaphragm thickness, thickening fraction and excursion, with patients more frequently assessed in the supine position and with an intercostal view. However, the real clinical utility of ultrasound for diaphragm assessment is still debated.

In relation to MPE, fluid drainage normally reduces the respiratory symptoms of most patients. Evidence as to whether pre-drainage motility of the diaphragm can predict the symptomatic outcome has been explored; in a small study (n=20 patients), ultrasound examination of the diaphragmatic shape prior to the pleural procedure did not predict how well the patients felt post-procedure, but excursion may be able to predict the response [55]. Although many studies have been presented within this topic over the past few years, there still remains a gap in the evidence that needs to be explored further [56].

Take-home message

- Many studies have explored the role of ultrasound in diaphragmatic assessment, but the evidence is divergent and heterogeneous, and there is a need for standardised definitions, scanning protocols, and larger, more uniform studies

Ultrasound in children

In adult pulmonology, emergency medicine and critical care, ultrasound is widely implemented with a solid evidence base [57, 58]. In the paediatric setting the evidence is less prominent, but is increasing, since the examination does not, for example, expose children to radiation or require movement to another room. Compared to conventional chest radiography, ultrasound has a high sensitivity (97%) and specificity (96%) for the detection of pneumonia in children [59]. Additionally, the sonographic consolidation dimension (measured on the largest consolidation surface) correlates with the serum C-reactive protein level. Despite the limited number of patients (n=49), one study suggested ultrasound as a tool for monitoring hospitalised infants and children [60]. In accordance with published literature, the presented abstracts further indicate that ultrasound may replace chest radiography as the first-line imaging modality in children with suspected pneumonia [61].

Another major topic that many researchers have explored, but which is not yet well anchored, is the role of ultrasound in diagnosing or monitoring ILDs. A pilot study of five children was presented exploring the feasibility of ultrasound and comparability of thoracic ultrasound and CT images [62]. The preliminary results demonstrated good correlation between the images. This result supports the main findings in one adult ILD study comparing ultrasound and high-resolution CT [63], but differs from another, which also explored ultrasound elastography for diagnosis and follow-up of ILD [64].

Take-home messages

- Ultrasound is an acceptable diagnostic tool for identifying pneumonia in children and potentially for monitoring purposes as well
- As in adults, the evidence for ultrasound in relation to ILD is divergent. So far, it is not possible to confirm how ultrasound should be used

Education and training

The increased interest, use and research in thoracic ultrasound has provoked an increased interest in educational approaches. Despite a steep learning curve, implementation of point-of-care ultrasound without simultaneous implementation of a structured, competency-based training programmes is a hazard to patient safety [65]. A regional survey revealed that 72% of residents had performed thoracic ultrasound or unsupervised pleural procedures before being a level 1 practitioner despite the Royal College of Radiologists' recommendations [66]. Half of residents had access to organised education and training of pleural skills, but only half responded that they had access to supervision for difficult procedures [67]. Even though training programmes are provided at a European and, in several countries, at a national level, there is plenty of room for improvement; all the way down to an institutional level, focus on competence should be prioritised [68].

In order to improve safety and reduce complications following pleural procedures, the British Thoracic Society has published safety standards for invasive procedures [69]. A study among respiratory registrars found that these checklists are not used enough, but that they are more likely to be used if they are available in a dedicated procedure room or next to the procedural equipment [70].

During an oral session on skills training in the field of respiratory medicine, the limited access to education and skills training due to COVID-19 restrictions was highlighted, as this is an immediate and direct threat to patient safety. Development of innovative methods for ensuring high quality and evidence-based education and skills training in setting with COVID-19 restrictions should be a high priority.

Take-home messages

- As the role of thoracic ultrasound increases, there is higher demand for structured training programmes and organised supervision in clinical settings
- More studies are warranted to explore the daily practices of education and supervision
- Goal-directed efforts should be made to ensure education and skills training is still possible despite COVID-19 restrictions

Conflict of interest: P.I. Pietersen reports personal fees for lecturing on lung ultrasound education and simulation-based training from TEVA outside the submitted work. B. Klap has nothing to disclose. N. Hersch has nothing to disclose. C.B. Laursen reports a fee for a lecture at a research symposium organised by AstraZeneca outside the submitted work. S. Walsh reports personal fees for consulting activity and an advisory board from Sanofi-Aventis, personal fees for an advisory board from Roche, grants and personal fees for a steering committee from Boehringer Ingelheim, personal fees for consulting activity and an advisory board from Galapagos, personal fees for consulting activity from OSIC, speaker fees from Bracco, a fellowship from the NIHR, and personal fees for consulting activity and an advisory board from Verocyte, outside the submitted work. J. Annema has nothing to disclose. D. Gompelmann reports lecture and travel fees from Pulmonx, AstraZeneca, Boehringer Ingelheim, Olympus, Chiesi, Berlin Chemie, Novartis and Uptake Medical outside the submitted work.

References

1 Slebos DJ, Klooster K, Koegelenberg CF, *et al.* Targeted lung denervation for moderate to severe COPD: a pilot study. *Thorax* 2015; 70: 411–419.

2 Slebos DJ, Shah P, Herth F. A double-blind, randomized, sham-controlled study of targeted lung denervation in patients with moderate to severe COPD. *Eur Respir J* 2018; 52: Suppl. 62, OA4929.

3 Slebos DJ, Shah PL, Herth FJF, *et al.* Safety and adverse events after targeted lung denervation for symptomatic moderate to severe chronic obstructive pulmonary disease (AIRFLOW). A multicenter randomized controlled clinical trial. *Am J Respir Crit Care Med* 2019; 200: 1477–1486.

4 Shah P, Valipour A, Pison C, *et al.* Targeted lung denervation in patients with moderate to severe COPD: AIRFLOW-2 crossover patient outcomes. *Eur Respir J* 2020; 56: Suppl. 64, 3775.

5 Hartman J, Augustijn S, Klooster K, *et al.* Pre-treatment lung function decline stabilizes up to 3 year after targeted lung denervation in COPD. *Eur Respir J* 2020; 56: Suppl. 64, 3776.

6 Klooster K, ten Hacken NH, Hartman JE, *et al.* Endobronchial valves for emphysema without interlobar collateral ventilation. *N Engl J Med* 2015; 373: 2325–2335.

7 Naunheim KS, Wood DE, Krasna MJ, *et al.* Predictors of operative mortality and cardiopulmonary morbidity in the National Emphysema Treatment Trial. *J Thorac Cardiovasc Surg* 2006; 131: 43–53.

8 Lenga P, Grah C, Ruwwe-Glösenkamp C, *et al.* Endoscopic lung volume reduction with endobronchial valves in very low D_{LCO} patients. *Eur Respir J* 2020; 56: Suppl. 64, 3778.

9 Klooster K, Hartman J, Slebos D. Endobronchial valves for emphysema are effective in patients with moderate hyperinflation in the presence of a clear target lobe. *Eur Respir J* 2020; 56: Suppl. 64, 875.

10 Lenga P, Grah C, Rückert J, *et al.* Outcome of surgical and endoscopic lung volume reduction with valves in patients with severe lung emphysema: current data of 246 patients with 3 months follow-up from a lung emphysema registry in Germany. *Eur Respir J* 2020; 56: Suppl. 64, 4095.

11 Simon M, Harbaum L, Oqueka T, *et al.* Endoscopic lung volume reduction coil treatment in patients with chronic hypercapnic respiratory failure: an observational study. *Ther Adv Respir Dis* 2017; 11: 9–19.

12 Rötting M, Polke M, Kriegsmann K, *et al.* Impact of endoscopic valve therapy on hypercapnia in patients with chronic hypercapnic failure based on a severe lung emphysema. *Eur Respir J* 2020; 56: Suppl. 64, 3777.

13 Hetzel J, Maldonado F, Ravaglia C, *et al.* Transbronchial cryobiopsies for the diagnosis of diffuse parenchymal lung diseases: expert statement from the cryobiopsy working group on safety and utility and a call for standardization of the procedure. *Respiration* 2018; 95: 188–200.

14 Herth F, Sun J, Mayer M, *et al.* Value of transbronchial lung cryobiopsy in patients suspicious of peripheral lung cancer. *Eur Respir J* 2020; 56: Suppl. 64, 3779.

15 Gnass M, Sola J, Orzechowski S, *et al.* Transbronchial lung cryobiopsy guided radial mini-probe EBUS for diagnosing peripheral lung lesions suspected of malignancy. *Eur Respir J* 2020; 56: Suppl. 64, 1578.

16 Ankudavicius V, Zemaitis M, Miliauskas S. Late breaking abstract – radial endobronchial ultrasound guided transbronchial cryobiopsy with fluoroscopy in the diagnosis of peripheral pulmonary nodule: first experience in the Hospital of LUHS Kauno klinikos. *Eur Respir J* 2020; 56: Suppl. 64, 1186.

17 Herth F, Vachani A, Criner G, *et al.* Multicenter, prospective trial: comparing yield and performance of virtual bronchoscopic navigation with and without radial-EBUS. *Eur Respir J* 2020; 56: Suppl. 64, 3475.

18 Kramer T, Wijmans L, De Bruin M, *et al.* Bronchoscopic needle based confocal laser endomicroscopy (nCLE) as a real-time detection tool for peripheral lung cancer. *Eur Respir J* 2020; 56: Suppl. 64, 5127.

19 Korrungruang P, Boonsarngsuk V. Diagnostic value of endobronchial ultrasound elastography for the differentiation of benign and malignant intrathoracic lymph nodes. *Respirology* 2017; 22: 972–977.

20 Teng B, Khan K, Al-Najjar H. The utility of elastography visual features to predict nodal malignancy during EBUS-TBNA. *Eur Respir J* 2020; 56: Suppl. 64, 2854.

21 Ernst A, Feller-Kopman D, Becker HD, *et al.* Central airway obstruction. *Am J Respir Crit Care Med* 2004; 169: 1278–1297.
22 Murgu SD, Egressy K, Laxmanan B, *et al.* Central airway obstruction: benign strictures, tracheobronchomalacia, and malignancy-related obstruction. *Chest* 2016; 150: 426–441.
23 Senitko M, Abraham G. Feasibility and safety of endoscopic microwave ablation for malignant central airway obstruction; a case series. *Eur Respir J* 2020; 56: Suppl. 64, 1204.
24 Sabath BF, Casal RF. Bronchoscopic ablation of peripheral lung tumors. *J Thorac Dis* 2019; 11: 2628–2638.
25 Sun J, Xie F, Chen J, *et al.* Late breaking abstract – microwave ablation *via* a flexible catheter for the treatment of nonsurgical peripheral lung cancer: a pilot study. *Eur Respir J* 2020; 56: Suppl. 64, 1571.
26 Kuijvenhoven J, Livi V, Szlubowski A, *et al.* Endobronchial ultrasound (EBUS) for T4 staging in patients with resectable NSCLC. *Eur Respir J* 2020; 56: Suppl. 64, 3473.
27 Troy LK, Grainge C, Corte TJ, *et al.* Diagnostic accuracy of transbronchial lung cryobiopsy for interstitial lung disease diagnosis (COLDICE): a prospective, comparative study. *Lancet Respir Med* 2020; 8: 171–181.
28 Higa K, Niwa T, Sato M, *et al.* Risk factors of transbronchial cryobiopsy complications: a retrospective study of 500 patients. *Eur Respir J* 2020; 56: Suppl. 64, 1819.
29 Daniels J, Nijman S, Ruiter G, *et al.* Transbronchial lung cryobiopsy in interstitial lung disease: safety & learning curve. *Eur Respir J* 2020; 56: Suppl. 64, 1190.
30 Kalpakam H, Bhat R, Bansal S, *et al.* Transbronchial lung cryobiopsy (TBLC) for interstitial lung disease (ILD) can be safely done in patients with multiple medical comorbidities. *Eur Respir J* 2020; 56: Suppl. 64, 1580.
31 Tomassetti S, Pavone M, Ravaglia C, *et al.* Clinical management implications of histologic information provided by lung biopsy in the multidisciplinary evaluation of interstitial lung diseases. *Eur Respir J* 2020; 56: Suppl. 64, 3780.
32 Nishikiori H, Chiba H, Hirota K, *et al.* Development of an artificial intelligence software to detect interstitial pneumonias. *Eur Respir J* 2020; 56: Suppl. 64, 3716.
33 Tibiletti M, Naish J, Heaton MJ, *et al.* Oxygen enhanced MRI biomarkers of lung function in interstitial lung disease. *Eur Respir J* 2020; 56: Suppl. 64, 4330.
34 Eaden J, Chan HF, Weatherley N, *et al.* Regional hyperpolarised 129-xenon diffusion-weighted MRI in patients with IPF. *Eur Respir J* 2020; 56: Suppl. 64, 4333.
35 de Koning HJ, van der Aalst CM, de Jong PA, *et al.* Reduced lung-cancer mortality with volume CT screening in a randomized trial. *N Engl J Med* 2020; 382: 503–513.
36 National Lung Screening Trial Research Team, Aberle DR, Adams AM, *et al.* Reduced lung-cancer mortality with low-dose computed tomographic screening. *N Engl J Med* 2011; 365: 395–409.
37 Calderwood C, Skyllberg E, Desai K, *et al.* Lung cancer screening – what does it mean for our practice? *Eur Respir J* 2020; 56: Suppl. 64, 4712.
38 Cui X, Zheng S, Heuvelmans M, *et al.* Validation of a deep learning-based computer-aided system for lung nodule detection in a Chinese lung cancer screening program. *Eur Respir J* 2020; 56: Suppl. 64, 4168.
39 Tanabe N, Sato S, Tanimura K, *et al.* CT evaluations of erector spinae muscle, emphysema, and airway disease for predicting mortality in COPD. *Eur Respir J* 2020; 56: Suppl. 64, 4913.
40 Lanclus M, Kendall I, De Backer W, *et al.* Ventilation-perfusion measures based on functional respiratory imaging (FRI) do correlate with exercise tolerance and PRO's in COPD. *Eur Respir J* 2020; 56: Suppl. 64, 2081.
41 Ye Z, Zhang Y, Wang Y, *et al.* Chest CT manifestations of new coronavirus disease 2019 (COVID-19): a pictorial review. *Eur Radiol* 2020; 30: 4381–4389.
42 Zerka F, Vaidyanathan A, Guiot J, *et al.* Late breaking abstract – development and validation of an automated radiomic CT signature for detecting COVID-19. *Eur Respir J* 2020; 56: Suppl. 64, 4152.
43 Fleischer J, Islam MT. Late breaking abstract – identifying and phenotyping COVID-19 patients using machine learning on chest x-rays. *Eur Respir J* 2020; 56: Suppl. 64, 4151.
44 Manoharan B, Shafiq M, Dawar U, *et al.* Late breaking abstract – chest radiography – a predictor of prognosis in COVID-19. *Eur Respir J* 2020; 56: Suppl. 64, 2079.
45 Sabria PT, Molina-Molina M, Aso-González S, *et al.* Late breaking abstract – lung ultrasound for severity assessment and outcome prediction of COVID-19 patients. *Eur Respir J* 2020; 56: Suppl. 64, 2777.
46 Costantini A, Bostantzoglou C, Blum TG. ERS International Congress, Madrid, 2019: highlights from the Thoracic Oncology Assembly. *ERJ Open Res* 2020; 6: 00131–2020.
47 Sharshar R, El-Shimy W, Elbadry A, *et al.* Study of ultrasound guided transthoracic fine needle aspiration and core needle biopsy in the diagnosis of peripheral pulmonary lesions. *Eur Respir J* 2020; 56: Suppl. 64, 2791.
48 Mei F, Bonifazi M, Rota M, *et al.* Diagnostic yield and safety of image-guided pleural biopsy: a systematic review and meta-analysis. *Eur Respir J* 2020; 56: Suppl. 64, 2789.
49 Quarato C, Venuti M, Lacedonia D, *et al.* Transthoracic shear wave elastography (SWE) in lung subpleural lesions: a preliminary report. *Eur Respir J* 2020; 56: Suppl. 64, 2783.
50 Yousefifard M, Baikpour M, Ghelichkhani P, *et al.* Screening performance characteristic of ultrasonography and radiography in detection of pleural effusion; a meta-analysis. *Emerg* 2016; 4: 1–10.
51 Psallidas I, Kalomenidis I, Porcel JM, *et al.* Malignant pleural effusion: from bench to bedside. *Eur Respir Rev* 2016; 25: 189–198.
52 Nozaki S, Shiroshita A, Tanaka Y, *et al.* Utility of thoracic ultrasound for detecting malignant pleural effusion: a systematic review and meta-analysis. *Eur Respir J* 2020; 56: Suppl. 64, 2786.
53 Jacobsen N, Konge L, Pietersen PI, *et al.* Clinical applications of contrast-enhanced thoracic ultrasound (CETUS) compared to standard reference tests: a systematic review. *Eur Respir J* 202056: Suppl. 64, 2785.
54 Parry S, Baldwin C, Granger C, *et al.* How is ultrasound imaging being used to assess respiratory musculature? A systematic review. *Eur Respir J* 2020; 56: Suppl. 64, 2979.
55 Castro-Anon O, Hassan M, Banka R, *et al.* Diaphragm ultrasound examination before and after fluid drainage in patients with malignant pleural effusion. *Eur Respir J* 2020; 56: Suppl. 64, 2787.
56 d'Hooghe J, Alvarez Martinez H, Pietersen PI, *et al.* ERS International Congress, Madrid, 2019: highlights from the Clinical Techniques, Imaging and Endoscopy Assembly. *ERJ Open Res* 2020; 6: 00116–2020.
57 Long L, Zhao HT, Zhang ZY, *et al.* Lung ultrasound for the diagnosis of pneumonia in adults: a meta-analysis. *Medicine* 2017; 96: e5713.

58 Ebrahimi A, Yousefifard M, Mohammad Kazemi H, *et al.* Diagnostic accuracy of chest ultrasonography *versus* chest radiography for identification of pneumothorax: a systematic review and meta-analysis. *Tanaffos* 2014; 13: 29–40.

59 Bloise S, La Regina D, Iovine E, *et al.* Lung ultrasound for diagnosis of community-acquired pneumonia in children: a comparison with chest X-ray. *Eur Respir J* 2020; 56: Suppl. 64, 5287.

60 Ciuca I, Marc M, Mircov FN, *et al.* Ultrasound pneumonia dimensions in children and inflammation. *Eur Respir J* 2020; 56: Suppl. 64, 1154.

61 Jones BP, Tay ET, Elikashvili I, *et al.* Feasibility and safety of substituting lung ultrasonography for chest radiography when diagnosing pneumonia in children: a randomized controlled trial. *Chest* 2016; 150: 131–138.

62 Delestrain C, Thouvenin G, Richard N, *et al.* Lung ultrasound in children with interstitial lung disease: a pilot study. *Eur Respir J* 2020; 56: Suppl. 64, 5288.

63 Maci F, Quarato CMI, Lacedonia D, *et al.* The role of transthoracic ultrasound in the study of interstitial lung disease: HRCT *versus* ultrasound pattern. *Eur Respir J* 2020; 56: Suppl. 64, 2781.

64 Abdullayeva Z, Aydoğdu M, Öztürk E, *et al.* Lung ultrasound and ultrasound elasthography for diagnosis and follow-up of interstitial lung diseases. *Eur Respir J* 2020; 56: Suppl. 64, 4176.

65 ECRI Institute. Top 10 Health Technology Hazards for 2020: Expert Insights from Health Devices. 2019. Available from: www.ecri.org/2020hazards

66 Royal College of Radiologists. Ultrasound Training Recommendations for Medical and Surgical Specialties. 3rd Edn. London, Royal College of Radiologists, 2017.

67 Abdullah Q, Azam A, Ganaie MB. Thoracic ultrasound (TUS) training: regional survey of respiratory specialty trainees (RST) from West Midlands Deanery (WMD). *Eur Respir J* 2020; 56: Suppl. 64, 4175.

68 European Respiratory Society. Thoracic Ultrasound Certified Training Programme. 2019. Available from: www.ersnet.org/

69 British Thoracic Society. National Safety Standards for Invasive Procedures (NatSSIPs) – Bronchoscopy and Pleural Procedures. London, British Thoracic Society, 2018.

70 Abdullah Q, Khalil M, Ahmed M, *et al.* Use of safety checklists for pleural procedures by respiratory trainees. *Eur Respir J* 2020; 56: Suppl. 64, 2780.