

Technologie (suite)

Assessment of expiratory flow limitation in chronic obstructive pulmonary disease: a new approach

Summary: This editorial of a study published by Dellacà et al explores the interesting novel data showing that the forced oscillation technique (FOT) can be useful for noninvasively detecting EFL during spontaneous breathing. Additionally, the study's relevance to better clarify the interpretations of FOT-measured respiratory resistance and reactance values is discussed.

Conclusion: The research work of Dellacà et al provides solid evidence that the forced oscillation technique is a simple procedure for detecting expiratory flow limitation during normal breathing. Future clinical studies should assess how FOT compares with other methods and should demonstrate the potential effectiveness of routine assessment of expiratory flow limitation in COPD patients during spontaneous breathing at rest and during exercise.

Farré R, Navajas D. Assessment of expiratory flow limitation in chronic obstructive pulmonary disease: a new approach. *Eur Respir J* 2004; 23: 187-188

Automatic detection of Expiratory Flow Limitation by Forced Oscillation Technique (FOT) during Non-invasive Ventilation (NIV)

Summary: The aim of this study was to implement forced oscillation technique (FOT) in a commercial bilevel mechanical ventilator and to evaluate its capability to detect EFL in sitting and supine COPD patients submitted to non-invasive ventilation (NIV), without external additional equipments. Expiratory respiratory reactance was measured in 13 COPD patients subjected to nasal BiPAP. Nine were studied supine and four were seated.

Conclusion: The data indicate that FOT can be implemented into commercial mechanical ventilators to automatically and reliably detect EFL during NIV. This information can help to set the expiratory positive airway pressure during NIV to the minimum pressure able to abolish EFL in COPD patients receiving nasal BiPAP.

Govoni L, Savi D et al. Automatic detection of Expiratory Flow Limitation by Forced Oscillation Technique (FOT) during Non-invasive Ventilation (NIV). Abstract 2012

Clinical characteristics of COPD patients with tidal expiratory flow limitation

Summary: Using Impulse Oscillometry (IOS) to identify COPD patients with EFL, a wide range of symptomology is found across the study's population. Of the 37.4% of patients studied, characteristics found included lower forced expiratory volume in 1 second values, greater hyperinflation, reduced exercise performance, and increased small airway impairment.

Impulse Oscillometry measures respiratory resistance and reactance during tidal breathing using sound waves of different frequencies to reach its conclusions.

Conclusion: It's long been known that small airway disease and EFL are features of COPD. It was shown that IOS can identify patients with EFL and that EFL is associated with more severe airflow obstruction, hyperinflation, and symptoms. EFL is suggested as a "treatable trait" and may provide an opportunity for therapeutic intervention.

Dean J, Kolsum U, Hitchen P, Gupta V, Singh D. Clinical characteristics of COPD patients with tidal expiratory flow limitation. *Int J Chron Obstruct Pulmon Dis*. 2017 May 22;12:1503-1506

* EFL : Expiratory Flow Limitation (limitation du débit expiratoire)

Limitation du débit expiratoire Preuves cliniques



La limitation du débit expiratoire (EFL*) est un état physiopathologique qui survient lorsque le débit expiratoire n'augmente pas alors que le patient augmente son effort expiratoire.

Un léger collapsus ou une obstruction des voies respiratoires - souvent associés à la position du corps et à d'autres facteurs liés au patient (obésité, apnée) - peuvent augmenter la fréquence de cet état mécanique qui, dans sa phase la plus aiguë, comme pour les patients atteints de BPCO, peut se produire pour un patient faisant de l'exercice ou au repos.

Bien que les EFL limitent fortement l'expiration, il a été prouvé que les méthodes positives, tant mécaniques que naturelles, augmentent significativement le débit respiratoire. Les articles qui suivent explorent le sujet des EFL dans quatre catégories distinctes : la définition de la physiologie des EFL et des caractéristiques de la maladie, ses implications cliniques, la ventilation mécanique et EFL et enfin, les nouvelles technologies pour évaluer les EFL.

Définition des EFL

Expiratory Flow Limitation definition, mechanisms, methods, and significance

Summary: In this five-point study, Expiratory (air) Flow Limitation (EFL) is defined, the mechanisms that can contribute to its development discussed, methods for detecting it explored, how dynamic hyperinflation and dyspnea can develop from it cautioned and lastly, the clinical aspects of having and treating the disease considered. The specifics of tidal breathing, at-rest exhalations vs. expiratory breathing during exercise, and where COPD is placed into the overall picture of air restriction are also detailed.

Conclusion: EFL is a significant mechanical constraint that all too frequently is seen in the COPD patient. The effect of EFL, as well as the onset of dynamic hyperinflation resulting from it, can rarely be reversed. Physicians should know to treat the first signs of EFL as early and as aggressively as possible.

Tantucci C. Expiratory Flow Limitation definition, mechanisms, methods, and significance. *Pulmonary Medicine Volume 2013, Volume 2013, Article ID 749860, 6 pages*

Dynamic Hyperinflation Is it worth measuring?

Summary: Dynamic hyperinflation, the inability to increase EFL, is a phenomenon found in patients suffering from chronic obstructive pulmonary disease. But dynamic hyperinflation is not seen universally in COPD patients and can be elusive to detect. Here the physiologic basis for dynamic hyperinflation is explored, its effects on patient exercise weighed and therapies considered.

Conclusion: Although dynamic hyperinflation is a significant variable in determining the intensity of patient's breathlessness, it is not the only factor in the limitations of the COPD sufferer and is not always present during the COPD sufferer's exercise.

Calverley. Dynamic Hyperinflation Is It Worth Measuring? *Proc Am Thorac Soc Vol 3, pp 239-244, 2006*

Définition des EFL (suite)

Hyperinflation and its management in COPD

Summary: The pathophysiology of dynamic hyperinflation (DH) is explored and its clinical consequences, such as dyspnea and cardiac dysfunction, examined. Therapeutic interventions and treatments directed to ameliorate and reduce dynamic hyperinflation are discussed, along with methods to measure both flow limitation and dynamic hyperinflation.

Conclusion: Flow limitation and dynamic hyperinflation are crucial functional changes that accompany COPD. While treatment may alleviate the impact of flow limitation and dynamic hyperventilation on the patient, both mechanisms worsen as COPD advances. Although measurement of dynamic hyperventilation may be done directly and indirectly, clinical use is limited by the lack of a standard method to measure DH or flow limitation during exercise.

Puente-Maestu L, Stringer W. Hyperinflation and its management in COPD. *International Journal of COPD* 2006;1(4):381–400

Tidal Expiratory Flow Limitation at rest as a functional marker of pulmonary emphysema in moderate-to-severe COPD

Summary: Chronic bronchiolitis and panlobular emphysema are two main diseases responsible for the development of COPD. The objective of the study was to assess if EFL is a functional marker more frequently linked to prevalent pulmonary emphysema rather than to prevalent chronic bronchiolitis in COPD patients. Forty consecutive stable COPD patients were evaluated, their EFL assessed in both sitting and supine positions. Chronic dyspnea was also scored.

Conclusion: EFL in sitting position is highly dependent by the severity of airflow obstruction in COPD patients. In these patients when EFL occurs in supine position it is associated with worse lung diffusion capacity and coefficient of diffusion and greater chronic dyspnea, reflecting the emphysematous rather than bronchiolitic prevalent phenotype of COPD.

Chiari S, Bassini S, et al. Tidal Expiratory Flow Limitation at rest as a functional marker of pulmonary emphysema in moderate-to-severe COPD. *COPD*, 11:33–38, 2014

EFL & implications cliniques

Flow limitation during resting breathing is associated with reduced exercise capability in COPD

Summary: The most significant symptom of COPD is flow limitation (FL), caused by peripheral airway collapse during expiration. In this case study, forced oscillation technique was used on a grouping of COPD patients to measure inspiratory-expiratory reactance. Spirometry and 6-minute-walk tests were used.

Conclusion: COPD patients that experience EFL during their resting breathing suffer through significantly poorer exercise capability.

Aarli B, Eagan T, Hardie J. Flow limitation during resting breathing is associated with reduced exercise capability in COPD. *European Respiratory Journal* 2014 44: P4879

The association of tidal EFL with exercise performance, exacerbations, and death in COPD

Summary: With tidal EFL frequently found in patients with COPD and usually detected by forced oscillations when within-breath reactance of a single-breath, within-breath reactance was measured over multiple breaths and tidal EFL with 6-minute walk distance and mortality. Spirometry and forced oscillation technique measurements were taken on eight occasions over a three-year period for 425 patients, grouped according to mean within-breath reactance. Respiratory symptoms, exacerbations, and hospitalizations were recorded with 5-year mortality statistics retrieved retrospectively.

Conclusion: Patients with baseline results saw a deterioration in exercise performance, with more exacerbations and greater hospitalizations. Those with moderate airway obstruction saw a higher mortality with this study.

Aarli B, Calverley P et al. The association of tidal EFL with exercise performance, exacerbations, and death in COPD. *Int J Chron Obstruct Pulmon Dis*. 2017 Jul 26;12:2179–2

Differences In Forced Oscillation Technique between healthy individuals, obstructive sleep apnoea and Obesity Hyperventilation Syndrome

Summary: Forced Oscillation Technique (FOT) has been used to demonstrate expiratory flow limitation (EFL) in chronic obstructive pulmonary disease. However, this technique has not been widely used in the obese population.

In this study three different groups—Obesity Hyperventilation Syndrome (OHS), healthy individuals and the apnoea patients, were studied for EFL results when FOT was introduced; obese individuals breathing at lower lung volumes are more likely to develop EFL. Here an extra step was added to the research by introducing patients with obstructive sleep apnoea and comparing the results across groups of OSA, OHS, and healthy volunteers.

Conclusion: Although patients with obesity and apnoea breathing indeed experience greater possibilities of EFL, breathing obstruction was more evident in the OHS group over the Obstructive Sleep Apnoea (OSA) group. Patient positioning was found to be a more significant factor in the OHS group.

Mandal S, Vaughan-France A et al. Differences In Forced Oscillation Technique between healthy individuals, obstructive sleep apnoea and Obesity Hyperventilation Syndrome. *Thorax* 2014 69: A31

EFL & ventilation mécanique

Expiratory Flow Limitation during mechanical ventilation

Summary: The report summarizes the methods used to detect EFL during mechanical ventilation that could potentially influence outcomes. EFL, Dynamic Airway Compression, Wave Speed and Viscous Flow Theories are among many other topics discussed. The exacerbation of EFL_T in COPD patients is also considered as is EFL_T in the obese.

Conclusion: Various methods can confirm EFL_T with relative ease and, if diagnosed early enough, the effectiveness of current ventilation procedures - bronchodilator and vasodilator among them - is increased. Finding a simpler, if not fully automated, system for the detection of EFL_T is required for future study and implementation.

Junhasavasdikul D, Telias I et al. Expiratory Flow Limitation during mechanical ventilation. *Chest Journal* Published online: February 09, 2018

COPD: algorithms and clinical management

Summary: This editorial of a study published in the same journal, continues to explore the unique analytical methodology used to define COPD heterogeneity. Clinical implications, methodology and validation, and individualization of treatment are explored. In addition, a much simpler clinical treatment of COPD exposed in the original study, is reiterated.

Conclusion: Algorithms can indeed be developed with simple clinical variables that will be useful for stratification and risk assessment. The findings also reinforce the generally accepted medical assessment that not all COPD patients are equal in their symptomology. In the end though, what is most important is less what group the patient falls into but what is the best treatment that can be offered.

Faner R, Agusti A. COPD: algorithms and clinical management. *Eur Respir J* 2017; 50:1701733

Effects of extrinsic positive end-expiratory pressure on work of breathing in patients with chronic obstructive pulmonary disease

Summary: The effects of extrinsic positive end-expiratory pressure (PEEPe) on work of breathing (WOBp) was investigated in 10 ventilated patients with COPD. Respiratory mechanics were monitored. Intrinsic positive end-expiratory pressure (PEEPi) was measured at varying percentages of PEEPe. Pulmonary mechanics plus heart rate, blood pressure and blood gas were measured.

Conclusion: Positive end-expiratory pressure can significantly reduce work of breathing in patients and improve the coordination between the patient and the ventilator. WOBp decreases by narrowing the difference between the alveolus pressure and the central airway pressure at the end of expiration when PEEPe is applied.

Kong W, Wang C et al. Effects of extrinsic positive end-expiratory pressure on work of breathing in patients with chronic obstructive pulmonary disease. *Chinese medical Journal* 2001; 114(8):791–794

Technologie

Detection of expiratory flow limitation in COPD using the forced oscillation technique

Summary: EFL during tidal breathing is a major determinant of dynamic hyperinflation and exercise limitation in COPD. It's hypothesized that tidal flow limitation would significantly reduce the total respiratory system reactance during expiration, and that this reduction could be used to reliably detect if EFL was present. To test this, seven healthy subjects and 15 COPD patients underwent forced oscillations during quiet breathing. COPD breaths were analysed and classified.

Conclusion: Forced oscillation technique is simple to use, sensitive and specific. Findings indicate that within-breath respiratory system reactance provides an accurate, reliable and noninvasive technique to detect expiratory flow limitation in patients with COPD.

Dellacà R, Santus P et al. Detection of expiratory flow limitation in COPD using the forced oscillation technique. *Eur Respir J* 2004; 23: 232–240

Noninvasive detection of expiratory flow limitation in COPD patients during nasal CPAP

Summary: The difference between mean inspiratory and expiratory respiratory reactance measured with forced oscillation technique at 5 Hz allows the detection of expiratory flow limitation (EFL) in COPD patients breathing spontaneously. The aim of this study was to evaluate whether this technique can be applied to COPD patients during noninvasive pressure support. Seven COPD patients were subjected to nasal CPAP in sitting and supine positions.

Conclusion: Data suggest that the forced oscillation technique may be useful in COPD patients on nasal pressure support by identifying continuous positive airway pressure levels that support breathing without increasing lung volume, which in turn increase the work of breathing and reduce muscle effectiveness and efficiency.

Dellacà R, Rotger M et al. Noninvasive detection of expiratory flow limitation in COPD patients during nasal CPA. *Eur Respir J* 2006; 27: 983–991