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EDITORIAL

Sniff nasal inspiratory pressure: simple or too simple?

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Respiratory muscle weakness, be it of acute or chronic onset, is a potentially threatening condition. Weakness of inspiratory muscles generates an imbalance between muscle load and capacity that, when severe enough, leads to hypercapnic respiratory failure. Conversely, weakness of expiratory muscles impairs cough and airway clearance and favours lung atelectasis and infection. Dysfunction of both respiratory muscle groups commonly precipitates acute respiratory failure in neuromuscular disorders. In recent years, the importance of respiratory muscle assessment has been recognised and a variety of tests has been proposed [1, 2].

The strength of inspiratory muscles can be assessed either by volitional or by nonvolitional tests. The volitional tests are simple, portable and inexpensive. Their main limitation lies in their dependence on maximal voluntary neuromuscular activation, which, in practice, is difficult to ascertain. In contrast, the cortical motor command is bypassed by nonvolitional tests such as phrenic nerve magnetic stimulation [3]. Phrenic nerve stimulation offers the most reliable measure of diaphragm contractility, but is not widely available because it requires expensive equipment. It must be added that phrenic nerve stimulation may overestimate the diaphragm strength that is actually available to the patient in case of upper motor neuron lesions [4]. Thus, notwithstanding their limitations, volitional tests remain on the first line and must be best exploited.

Maximum inspiratory pressure ($P_{I,max}$) is the classic volitional test of inspiratory muscle strength. It is measured as the highest mouth pressure sustained for 1 s during a maximum inspiratory effort against a quasi occlusion. Although simple in principle, the $P_{I,max}$ manoeuvre is difficult for many and requires a hermetic seal around the mouthpiece. As a consequence, low values may be due to true muscle weakness, a submaximal effort, or air leaks in the case of facial muscle weakness. The sniff is an alternative manoeuvre that is more natural and easier for most subjects. During a maximal sniff, there is strong activation of the diaphragm and of the scalene muscles [5, 6]. Thus, the sniff has proved valuable to assess diaphragm strength using transdiaphragmatic pressure (sniff P_{di}), or global inspiratory muscle strength using oesophageal pressure (sniff P_{oes}) [7, 8]. More recently, the method of sniff nasal inspiratory pressure (SNIP) was proposed as a non-invasive test of inspiratory muscle strength [9]. This very simple procedure consists of measuring peak nasal pressure in one occluded nostril during a maximal sniff performed from relaxed end-expiration through the contralateral patent nostril. During a vigorous sniff, the nasal valve of the patent nostril collapses and the pressure measured beyond the collapsed segment closely reflects oesophageal pressure and, therefore, inspiratory muscle strength. Various types of nasal plugs have been used in the past, but portable manufactured systems are now available for measuring SNIP. Severe nasal congestion represents a limitation of the method because it hinders pressure transmission and leads to falsely low values.

Reference values have been established for SNIP in adults [10] and children [11, 12]. Interestingly, SNIP is similar in children and adults, despite a large difference in respiratory muscle mass. This peculiarity is probably due to the predominant activation of the diaphragm, which acts as a piston in the thoracoabdominal cavity. The ratio of diaphragm muscle mass to the axially projected area of the diaphragm varies little from childhood to adulthood, and explains the relative stability of maximal P_{di} across ages [13, 14]. SNIP is often higher than $P_{I,max}$ in healthy subjects. Initially, this is surprising, as a loss of force would be expected during such a dynamic manoeuvre due to the force–velocity relationship of muscles. This apparent paradox is probably explained by a more complete neuromuscular activation during the SNIP test, which is much easier to perform. However, the limits of agreement between these two tests are wide. This indicates that SNIP and $P_{I,max}$ are not interchangeable and should be considered as complementing one another for the assessment of inspiratory muscle strength.

In this issue of the *European Respiratory Journal*, LOFASO *et al.* [15] report a study assessing the number of sniffs that are necessary to obtain a true maximal SNIP. This is particularly relevant because the main limitation of volitional tests remains the uncertainty about the achieved neuromuscular activation. Earlier observations have suggested that the learning effect is completed within the first 10 maximal sniffs [10]. LOFASO *et al.* [15] asked a group of healthy subjects to perform 40 consecutive maximal sniffs and analysed them in sets of 10. It was found that the best SNIP was 6% higher in sniffs 11–20 than in sniffs 1–10. The SNIP then reached a plateau after the twentieth sniff. The study was extended to a large group of patients performing 20 consecutive sniffs and, again, the best SNIP was 10% higher in the second set of 10 sniffs than in the first set. These results are remarkably consistent with some previous observations made in different settings. In a small group of patients with amyotrophic lateral sclerosis (ALS) who were examined repeatedly, the best of 20 SNIP values exceeded the best of the first 10 by 7% [16]. In a larger group of patients with asthma or various medical conditions, the best of 15 SNIP values was higher than the best of the first 10 by

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10% [17]. Thus, it appears clear that the maximal SNIP will be achieved with greater certainty after 20 sniffs than after only 10. However, the gain is relatively small after the tenth trial and it may be questioned whether it is worth imposing this on the patient. To solve this dilemma, the authors proposed to perform >10 sniffs only when SNIP is slightly below normal or when it is used to monitor functional decline over time. This recommendation appears to be a reasonable compromise between scientific rigour and practical considerations. Some studies with a similar goal have recommended between nine and 20 trials for achieving a true $P_{I,max}$ [18, 19], but such long procedures have neither been adopted in clinical practice nor been endorsed by international guidelines [2].

What has been learned since the introduction of SNIP in to the clinical arena? This test appears particularly suited to neuromuscular weakness because it obviates the use of a mouthpiece and because it is easily mastered by the vast majority of patients. Among 126 young patients with neuromuscular or skeletal disorders, all could perform the SNIP, whereas 10 could not perform the $P_{I,max}$ [20]. Among 258 adult patients with neuromuscular weakness, eight were unable to perform the SNIP and nine the $P_{I,max}$ [21]. In patients with neuromuscular disorders, SNIP was found to be the main determinant of vital capacity [20]. However, patients with severe neuromuscular disorders may have difficulty in performing a rapid sniff, leading to a potential overestimation of muscle weakness by SNIP [21]. This limitation implies that the assessment of severe muscle weakness should not rely on SNIP only, but should include other tests like $P_{I,max}$, vital capacity, nocturnal oximetry or arterial blood gases. In patients with restrictive thoracic disease treated with noninvasive ventilation, a correlation was found between the fall in the Epworth sleepiness score and the gain in sniff P_{oes} and SNIP, whereas no correlation existed with twitch P_{di} obtained by phrenic nerve stimulation [22]. This discrepancy may suggest that activation of respiratory muscles by volitional tests such as SNIP is hindered by excessive somnolence. Similarly, a reduced central command has been hypothesised to explain the fall in SNIP and $P_{I,max}$ documented during experimental hypobaric hypoxia [23].

The SNIP test has been used by different groups to assess patients with ALS. SNIP seems to be more frequently feasible than $P_{I,max}$ in advanced disease [16, 24], but is often difficult to perform for patients with bulbar involvement [25]. SNIP appears to be of some value in monitoring the evolution of disease, showing a linear decline [16] and proving to be better than $P_{I,max}$ and vital capacity in predicting hypercapnia [4, 25]. As with other indices of respiratory muscle strength, SNIP showed moderate-to-strong correlations with different scores of quality of life in ALS [26]. Finally, a SNIP value <40 cmH_2O was associated with a median survival of 6 months, and a value <30 cmH_2O with a median survival of 3 months [24].

The transmission of rapid pressure changes from the alveoli to the upper airways is altered in the case of airflow limitation [27], and indeed, SNIP underestimated sniff P_{oes} on average by 14% in patients with acute asthma [17] and by 19% in patients with stable COPD [28]. This limitation has to be considered and may explain part of the increase seen in SNIP after lung volume reduction surgery (LVRS) [29]. Nevertheless, after an initial gain, SNIP was shown to increase further 9 months after LVRS, when no further change occurred in forced expiratory volume in one second or functional residual capacity, suggesting a possible delayed muscle adaptation [30].

A knowledgeable author once advised: ''Make everything as simple as possible, but not simpler.'' Simplicity is the main asset of sniff nasal inspiratory pressure, but it carries limitations. Due to its ease of use, sniff nasal inspiratory pressure proves valuable as a first-line tool for diagnosing respiratory muscle weakness. The well-founded and practical recommendations of LOFASO *et al.* [15] will help to disseminate this procedure more widely. Nevertheless, in some patients, inconclusive results with simple tests will require a formal assessment, including nonvolitional tests to confirm or refute respiratory muscle weakness.

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