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EDITORIAL

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Humidification during oxygen therapy and non-invasive ventilation: do we need some and how much?

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Oxygen supply and non-invasive ventilation (NIV) are the first-line therapy for respiratory failure. However, despite the increasing use of NIV and continuous positive airway pressure (CPAP) to treat acute respiratory failure and the long use of oxygen therapy, there is, surprisingly, no explicit recommendation on the level of additional humidification that is necessary and how to deliver it. In fact, it is still not 100% clear if any humidification is actually required at all. There are a lack of studies addressing the benefit of humidification during oxygen therapy in terms of outcome, and those focusing on comfort have yielded contrasting results [1, 2]. A survey of intensive care unit (ICU) physicians' practices in terms of humidification during NIV [3] revealed that 25% of the respondents did not use any sort of humidification device. This result is consistent with the preliminary results of a multicenter survey in which six of the 15 participating centers reported having no humidification protocol during NIV [4]. Thus, the question of whether or not the absence of humidification affects NIV outcome remains unanswered. In this same study [4], the rate of difficult intubation following NIV failure was 5.4%; among this very small group, 45% patients had no humidification. This lack of data for any association between the lack of humidification with NIV failure and difficult intubation does not mean, however, that patient comfort is not affected by the absence of humidification, as is the case during nasal CPAP for obstructive sleep apnea.

The two questions that then arise are "how much humidity is necessary?" and "how should this be delivered?".

Partial answers to these important questions are provided by two articles in this issue of *Intensive Care Medicine* [5, 6] which report elegant studies combining bench and in vivo measurements. The objectives of the study of Chanques et al. [6] were to assess and compare the discomfort of non-intubated patients receiving oxygen through either a cold water bubble humidifier (BH) or a heated humidifier (HH) and to measure the hygrometric properties of oxygen of the two systems. Discomfort, including dryness of the mouth, was assessed using a numerical rating scale. The first important result was that one-half of the 30 patients experienced no or only minor discomfort with either system, thus raising the question of whether additional humidification was needed in those patients; unfortunately, there was no control group without any humidification for comparison. The second important result was that only one-third of the patients reported severe discomfort; these represent the patient population for whom additional humidification should be considered. The severity of all dryness discomfort symptoms was assessed to be less with the HH than with the BH device,

but mouth and throat dryness were the only symptoms showing a significant reduction. Disappointingly, however, the HH device was not able to totally alleviate the symptoms in these patients despite much higher humidity outputs, as measured on the bench study. Minor limitations to this study should, however, be noted. First, the patient population was relatively small, and the study interval was short. Second, despite efforts to disguise the identity of the devices, one can question if the study was really blinded because the gas temperature of the HH was 8°C higher than that of the BH. Although not significant, there was indeed a greater sensation of heat in the mask of the HH device. Lastly, oxygen flows were not very high.

This latter point is the key issue. One must bear in mind that patient inspiratory flows may vary between 30 and >120 L/min during respiratory failure [7]. This means that the proportion of humidified inspired gas with the device (BH or HH) can be very small (below 10%), thus questioning the clinical benefit of humidifying <10% of the inspiratory flow.

What should be done with patients receiving much higher oxygen flows? Intuitively, one can hypothesize that the higher the oxygen flow, the greater the discomfort (and hence the need for humidification). Surprisingly, such a correlation was not found by Chanque et al. [6], although one was found by Miyamoto and Nishimura [1]. A true benefit of the HH device during oxygen therapy may be the possibility to administer much higher flows in patients with hypoxemic respiratory failure using the same HH device studied by Chanques et al. but set with an air-oxygen blender allowing approximately 50–60 L/min 100% FiO_2 (Optiflow) in order to meet the patients' needs in terms of inspiratory flow [8]. Our personal experience with this device is limited to a small number of patients with acute respiratory failure. Nonetheless, some of these required up to 60 L/min 100% FiO_2, which they tolerated perfectly for several days. Obviously, such a promising technique will need to be thoroughly assessed on both clinical and economical grounds.

So how should humidification be managed? The results of Chanques et al. [6] show a wide inter-patient variability in terms of discomfort experienced during oxygen therapy and incomplete discomfort relief with either device, indicating that an individual assessment should be performed before humidification is added to the therapy. If patients report moderate to severe discomfort, the BH should be the first device attempted for obvious economic reasons. Should that not be enough, the HH device could then be set in place. Further studies will have to confirm the benefit of this technique in a much larger number of patients and settings (higher flows of oxygen, general ward) and specifically address the issue of its cost-effectiveness.

As mentioned above, no clear recommendation exists on the use of humidification during NIV. In this context, Lellouche et al. [5] provide us with important information. These researchers measured water content during NIV with either a heat and moisture exchanger (HME), a HH or no humidification and compared these results according to the type of ventilator used (turbine or ICU ventilator). They found that in the absence of humidification, gas humidity was very low with an ICU ventilator (5 mgH_2O/L) but equivalent to the ambient air hygrometry with a turbine ventilator at minimal FiO_2 (12.5 mgH_2O/L). The HME and HH had comparable performances (25–30 mgH_2O/L), but the effectiveness of HME was reduced due to leaks, while the performance of the HH was reduced by elevated ambient air and ventilator output temperatures. During CPAP, dry gases (5 mgH_2O/L) were less tolerated than humidified gases; there was no difference in tolerance between 15 and 30 mgH_2O/L.

These data suggest that the minimal level of absolute humidity required during NIV is that >15 mgH_2O/L. Prior to this study, such data were lacking, explaining why humidification practices have varied so much among physicians [3, 4]. Although experts agree that 30 mgH_2O/L is the minimal humidification requirement necessary to ensure adequate gas conditioning during invasive ventilation [9], this figure could not be translated to NIV, during which the upper airways (where most of the inspired gas is heated and humidified) is not bypassed. Endotracheal tube occlusion has been clearly identified as one of the most dangerous risks faced by the patient with humidification during invasive ventilation [9], but those encountered during NIV are less well documented. Noticeably, patient discomfort could arise from dry inspired gas, but to what extent this discomfort can lead to NIV failure is unknown. The accumulation of dried secretions in the oropharynx that can either be aspirated or impede tracheal intubation if required may be another complication of insufficient humidification. As mentioned above, this has been reported in a very small fraction of patients undergoing NIV [4]. The results of Lellouche et al. seem to indicate that additional humidification is necessary, at least for comfort reasons. The question then arises as to which device enables adequate humidification. Physiological studies have shown that the use of HME during NIV leads to an increase in patient work of breathing because of the dead space added to the circuit [10, 11]. Although it is possible to surmise that this phenomenon could be reduced with a smaller HME [12], the authors of these studies [10, 11] recommended not using HME during NIV because this augmentation could affect outcome by increasing the NIV failure rate. Surprisingly, a large randomized controlled trial failed to confirm these observations and unexpectedly found a trend towards increased intubation rate and even mortality among patients on the HH in comparison with those on the HME [13], thereby casting doubt on the recommendation not to use HME. Lellouche et al. present additional evidence supporting the use of HME during NIV by showing that despite a reduction in absolute humidity in the presence of leaks, HME were able to provide absolute humidity >15 mg/L H_2O. Finally,

Lellouche et al. [14] confirmed the crucial importance of having an HH with an algorithm that compensated for unfavorable conditions (high ambient air and high output ventilator temperature), an observation they had already made during invasive ventilation.

However, areas of uncertainty do remain. The level of 15 mg H_2O/mL is based on respiratory discomfort rated by healthy volunteers. This raises several questions, one of which is: is the rating of discomfort comparable between healthy volunteers and patients in respiratory distress? Recent data show that the language of breathlessness differs between chronic obstructive pulmonary disease (COPD) and non-COPD patients [15], and the same could hold true for discomfort. With the same line of reasoning, is 15 mg H_2O/mL enough in patients with acute respiratory failure (by comparison with healthy volunteers)? It is conceivable that higher levels may be required in these patients. Third, how far is discomfort correlated with humidification requirements and, ultimately, with NIV failure? As indicated above, the considerable increase in the work of breathing observed with HMEs in physiological studies did not (contrary to what was expected) translate into greater NIV failure rate in a randomized study [13]. It may well be that factors other than discomfort affect NIV outcome.

Both of the studies reported here have been instrumental in providing a number of answers to the often overlooked issues associated with the daily management of patients with acute respiratory distress. Based on their findings, one could recommend that additional humidification during oxygen therapy is not necessary in every patient and that discomfort should be monitored in order to identify when and with which device it should be relieved. In terms of NIV, the addition of humidification to the treatment improves patient comfort, and this can be adequately achieved with either HH or HMEs even in the presence of leaks. For evident economical reasons, HME should be the first device attempted. Further studies will have to determine the efficacy of HH with higher oxygen flows and, most certainly, the potential for very high flow humidified oxygen therapy, but considerable progress has already been made due to the results of the two studies reported here [5, 6], which will, undoubtedly, assist in the development of future guidelines and consensus statements.

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