**Author’s response to reviews**

**Title:** Impact of leaks and ventilation parameters on the efficacy of humidifiers during home ventilation for tracheostomized patients: a bench study.

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Reviewers' comments

1. I have read the manuscript with extreme interest, as I believe that the airway humidity in the ventilated patient is an extremely important point from a clinical point of view but often neglected and disregarded by many physicians.

This study, however, is focused on a particular subpopulation of patients who are under mechanical ventilation with tracheostomy at home and in this particular setting I believe that the risks associated with the administration of excessive airway humidity (water overload) and the risks associated with formation of condensation (almost unavoidable) with consequent increased infectious risk. Therefore the use of simple HME could be perhaps a good compromise between risks and benefits and practicality of use.

Thank you for your comment. Indeed, we confirm that our study focuses on a subpopulation of patients under mechanical ventilation at home with tracheostomy and the purpose of our study was to test heated humidifiers.

As also under discussion, the set-up of the bench study is valid, especially the feature of positioning the test lung inside a conditioned chamber at 34 °C to better simulate the real situation.

Despite this, the manuscript presents many critical issues:
1. You test old-fashioned active humidifiers according to very recent guidelines and therefore probably were not manufactured for those purposes of HA and HR and T.

Thank you for your comment. We include in this study some representative home-use humidifiers which are still used in the field by home healthcare providers (except for D900 (Resmed) which is not use anymore in France).

The guidelines have not changed for several years with regard to the objective of absolute humidity, which remains 33 mg/l.

The parameters such as absolute, relative humidity and temperature are chosen for the purpose of comparing the capability of humidifying of these devices.

2. The calculation of water consumption is not clear. To calculate the consumption of water you state as follows: "water consumption was assessed as a percentage of the threshold flow rate, corresponding to the water flow rate required to empty the reservoir in 8 hours". I do not agree and do not understand this calculation, I always prefer data from measurements. It is not clear how you did it.

It is also very strange that a humidifier produces more absolute humidity by consuming less water (compare between fig.3 and fig.4). Something wrong....

We agree that the presentation of water consumption was not clear. In the current version, the water consumption is simply presented as flow rate (ml/hour), and we add estimated time to empty the water reservoir (according to each humidifier).

In the previous version, because of different reservoir volume between humidifiers, for each device, the water consumption rate was presented as the percentage of a reference flow rate corresponding to 8-hour use, in order to normalize the flow rate to volume of the reservoir. We agree that these normalized flow rates are not comparable between devices (old figure 4) and may cause confusion. Consequently, some humidifiers that produce more AH appear to consume less water according to old Figures 3 and 4.

3. Very poor data display both in results and in additional files.

You describe the statistical method used to compare the performance of the various humidifiers (Kruskal-Wallis method with p <0.05), but the results are not clear to me at all. Even the "additional files" are not of easy and immediate interpretation.

Thank you for your comment and the results are now presented differently (new Figure 3). The differences in absolute humidity between vented and valve circuit are highlighted for same conditions.
The absolute humidity is significantly different (p<0.05) between devices and between test conditions.

4. In the description of data acquisition there may be a writing error: "The measurement period begins 5 minutes after the plateau and lasts 10 minutes, as shown in figure 2.

The plateau "was defined as the absence of temperature greater than 1 ° C and absolute humidity variation greater than 5%" (also these "defined" data ...). Sample rate: 1 Hz; N: 300 points."

If you record from 10 minutes to 1 Hz, the sampled points should be 600 and not 300.

Thank you for pointing out this mistake. Indeed, the number of points is 600.

6. In the discussion you state that "a humidification for invasive provision cannot be provided. I do not understand why." I would almost say the opposite.

If we well understand, the text that you mention in discussion section is “We therefore confirm that a humidifier intended for noninvasive ventilation or CPAP (such as the HC150) cannot provide sufficient humidification during invasive ventilation regardless of the conditions”.

As stated by the manufacturer, the intended use of HC150 is only for non-invasive ventilation, and our results confirms this point. We think that it is important to raise awareness among physicians of this point as this humidifier is sometimes use in invasive ventilation

2. In the study, Haziot et al. compared humidification performance of five heated humidifiers under several respiratory conditions. Bench study is a powerful tool to investigate if medical devices work because we can compare them under same condition. However, the authors should be careful to make the settings as much as same to a real life physiology. There are several important issues in the study.

Even during short period, like during operation, lung protective strategy is considered to be essential. Six-hundreds of tidal volume is fairly high, and I don't understand the reason why the author chose 600 and 1000 mL of tidal volume in volume control ventilation. The measurements were performed at 12/min of breathing frequency only. Humidification performance is more influenced by minute volume than tidal volume.

Thank you for your comment. We have chosen Vt = 600 ml because it corresponds to a common tidal volume that can be frequently seen in patients, and Vt= 1000 ml corresponds to extreme cases (as it is sometimes used for phonation for tracheostomized patients). We test both common and extreme cases. We have chosen breathing frequency = 12 cycles/min because it relates to patient’s breathing frequency at rest.

The minute volume is influenced by both tidal volume and breathing rate. In this respect, two minute volume values are considered in the current study, while only one breathing rate value =
12 cycles/min is applied. Further study is need to see the impact of breathing rate on humidification.

Response of hygrometer is slow, and it is so tough to measure accurate humidity under dynamic flow, like during mechanical ventilation. Both inspiratory and expiratory gases influence measurements. Without separating inspiratory from expiratory gas, humidification cannot be measured accurately. What is a response time of hygrometer? The authors should present two kind of response time, when humidity increases, and decreases.

Thank you for raising this point. Indeed, the reaction time of hygrometer is long comparing to breathing cycles. The reaction time of the hygrometer used in the current study (Testo 645 with probe 06362142) is 30 seconds.

However, according to our method, we started measurement when the humidity becomes stable, i.e., after a 5-minute plateau which is characterized by a variation in relative humidity less than 5%, and the obtained results on the current bench model show that variation in humidity between inspiration and expiration is not significant, and becomes a stable value at the end. We measured the mean humidity value during 10-minute stable phase. The reaction time of hygrometer has little impact on the measurement.

Figure 1 is a key figure, while it is poorly drown and figure legend is not appropriate. I am afraid the readers have a difficult time to follow it.

Thanks. The figure 1 is replaced by a new one.

When leak port was open, how much is leak flow (or how much is total minute volume from a ventilator)?

As we stated in the method section, we used a calibrated leak port to simulate unintentional leak. The leak is 24 L/min at 10 cmH2O. The actual leak flow is proportional to the airway pressure.

Water consumption is also important information, however it is tough to understand the result. Why didn't the authors present simply water consumption? For example gram/hour is very easy to understand.

Thank you for your comment. Same question is addressed for Reviewer 1 and please see above for the answer.