

Online data supplement

Exhaled air dispersion during high flow nasal cannula therapy versus CPAP via different masks

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Image analysis

We estimated normalized smoke concentration in the exhaled air from the light scattered by the particles. The analysis was based on principle that the intensity of scattered light was proportional to particle concentration under the conditions that the intensity of laser illumination and the size and shape of the smoke particles were constant (monodisperse).¹

Image capture and frame extraction

Motion video of at least 20 breathing cycles at specified air flow rate was captured and individual frames extracted as gray scale bitmaps for intensity analysis. Frames are extracted from the beginning of each inspiration, to generate an ensemble average for the corresponding instant of the respiratory cycle.²⁻¹⁰ The time at which the normalized concentration contours spread over the widest region, from the nostrils of the HPS, was chosen for the ensemble average to estimate the greatest dispersion distance. This was found to be approximately at the mid-respiratory cycle.²⁻¹⁰

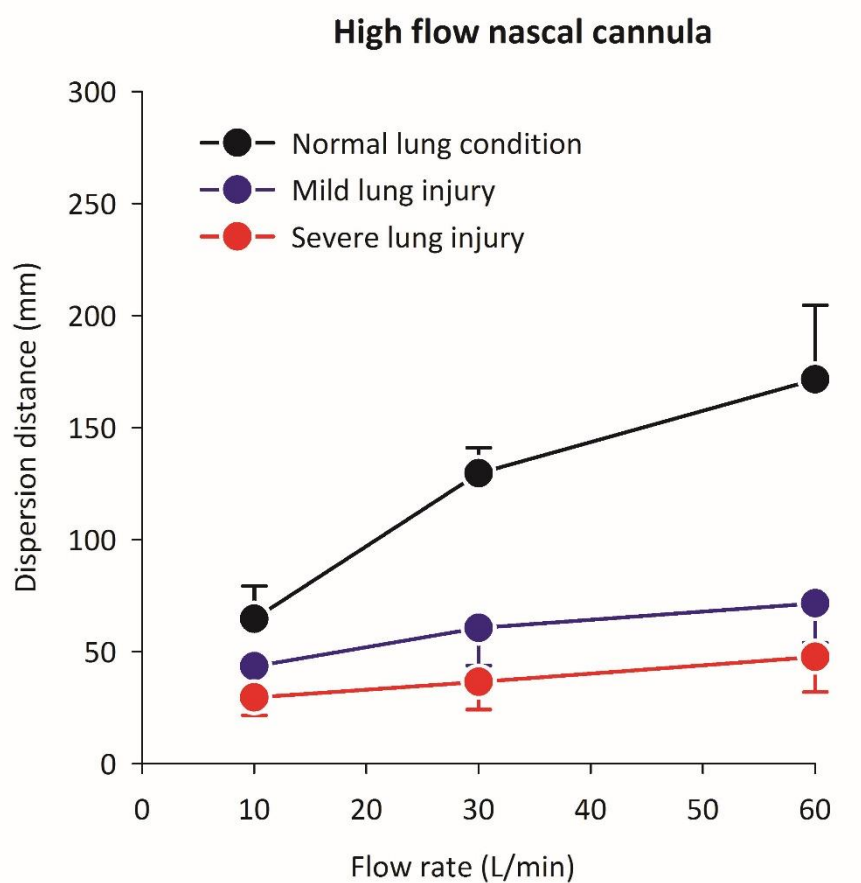
Intensity averaging and concentration normalization

All gray scale frames were read into a program specifically developed for this study (MathCad 8.0, Cambridge, MA, USA) along with background intensity images taken with the laser switched off.²⁻¹⁰ The background intensity image was subtracted from each frame, pixel by pixel to remove any stray background light and the pixel intensity values were averaged over all frames to determine the ensemble averaged intensity. The resulting image was the total intensity of light scattered perpendicular to the light sheet by the smoke particles and was directly proportional to smoke concentration under the conditions mentioned above. The image was normalized against the highest intensity found within the leakage jet plume to generate normalized particle concentration contours.²⁻

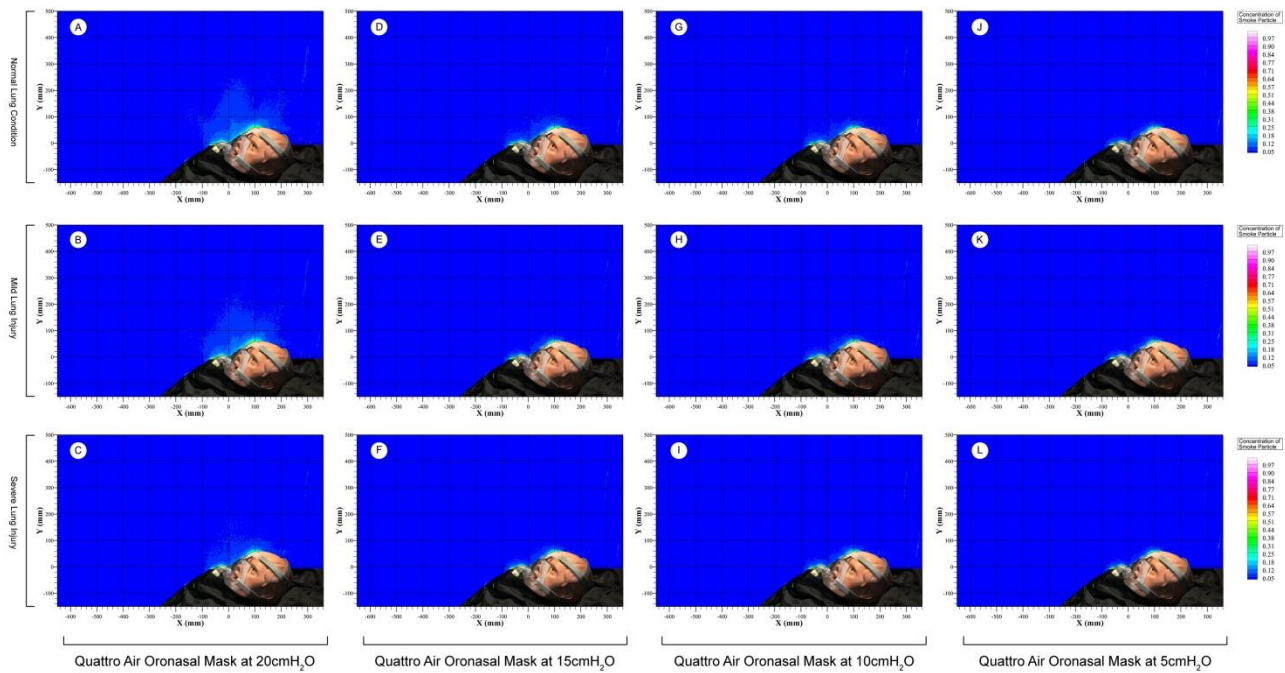
Supplemental References

1. Soo SL. Fluid dynamics of multiphase systems. Toronto, ON, Canada: Blaisdell Publishing Company, 1967.
2. Hui DS, Ip M, Tang JW, Wong AL, Chan MT, Hall SD, Chan PK, Sung JJ. Airflows around oxygen masks: A potential source of infection? *Chest* 2006;130:822-826.
3. Hui DS, Hall SD, Chan MT, Chow BK, Ng SS, Gin T, Sung JJ. Exhaled air dispersion during oxygen delivery via a simple oxygen mask. *Chest* 2007;132: 540-546.
4. Hui DS, Chow BK, Chu L, Ng SS, Lai ST, Gin T, Chan MT. Exhaled air dispersion and removal is influenced by isolation room size and ventilation settings during oxygen delivery via nasal cannula. *Respirology*. 2011;16:1005-1013.
5. Hui DS, Chow BK, Hall SD, Ng SS, Hall SD, Gin T, Chan MT. Exhaled air and aerosolized droplet dispersion during application of a jet nebulizer. *Chest* 2009;135:648-54.
6. Hui DS, Hall SD, Chan MT, Chow BK, Tsou JY, Joynt GM, Sullivan CE, Sung JJ. Non-invasive positive pressure ventilation: An experimental model to assess air and particle dispersion. *Chest* 2006; 130:730-740.
7. Chan MT, Chow B, Chu L, Hui DS. Mask Ventilation and Dispersion of Exhaled Air. *Am J Respir Crit Care Med* 2013;187:e12-14.
8. Hui DS, Chow BK, Hall SD, Chu LCY, Hall SD, Gin T, Sung JJY, Chan MT. Exhaled air dispersion distances during application of non-invasive ventilation via different Respironics face masks. *Chest* 2009;136:998-1005.
9. Hui DS, Chow B, Lo T, Ng SS, Ko FW, Gin T, Chan MT. Exhaled air dispersion distances during non-invasive ventilation via helmet masks and a total face mask. *Chest* 2015;147:1336-1343.
10. Chan MT, Chow BK, Lo T, Ko FW, Ng SS, Gin T, Hui DS. Exhaled air dispersion during bag-mask ventilation and sputum suctioning - Implications for infection control. *Sci Rep* 2018;8:198.

Supplemental figure S1. Changes of exhaled air dispersion with increasing flow rate and worsening degree of lung injury in high flow nasal cannula.



Supplementary figures S2a and b showing exhaled air dispersion from the ResMed Quattro face mask and a close up view of the mask respectively



Anti Asphyxia Valve (AAV) closed to atmosphere

A ring of tiny vent holes for deliberate leakage



Supplementary figure S3a and b showing box plots of exhaled air dispersion distances from the ResMed and Respiration nasal pillows respectively

