Increasing CPAP (Continuous Positive Airway pressure) leads to increasing transpulmonary pressure with increased activity of the Abdominal wall muscles to aid Expiration

M.Apps, M.Pavitt, A.Lewis, C.Orton, A.Sadaka, J.Garner, M.Hind, N.Hopkinson, M.Polkey, and J.Hull

NIHR Respiratory Biomedical Research Unit at Royal Brompton and Harefield NHS Foundation Trust London, UK.

Royal Brompton Hospital, Sydney St. London SW3 6NP contact email: M.Apps@rbht.nhs.uk

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Introduction

An understanding of the changes in intra-thoracic pressure in response to application of CPAP (Continuous Positive Airway Pressure) is important in the study of airway and ventilator mechanics.

Increasing CPAP makes it easier to breathe in and more difficult to breathe out. As the external pressure rises there is less airway collapse but increased air trapping even in those with normal lung mechanics.

In those with airways disease with air trapping and increased residual volume CPAP at high pressure may make CPAP and non invasive ventilation (NIV) treatment uncomfortable and reduce patient use overnight.

Methods

We studied 10 normal male subjects sitting wearing a CPAP facemask attached to a NIPPY 3 ventilator using CPAP and NIV settings.

Mouth pressure(Pmo) was measured directly at the facemask. Oesophageal (Poes) and intra-gastric (Pga) pressures were measured with balloon catheters.

The subjects sat at rest in a chair wearing a CPAP facemask. They were observed for 10 minutes at rest to obtain baseline data then 10 minutes at a setting of CPAP=5cmH_2O, 10 minutes at 10cmH_2O, 10 minutes at 15cm, followed by NIV at 15/5cmH_2O, and finally back to no CPAP with air pressure alone.

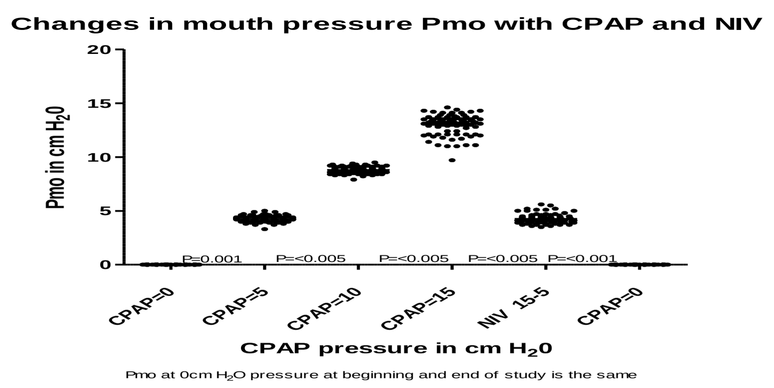
Throughout the study we recorded abdominal wall EMG with surface electrodes.

Data for analysis was taken from 10 breaths in the final 2 minutes of each period to allow for stabilisation of pressures and EMG.

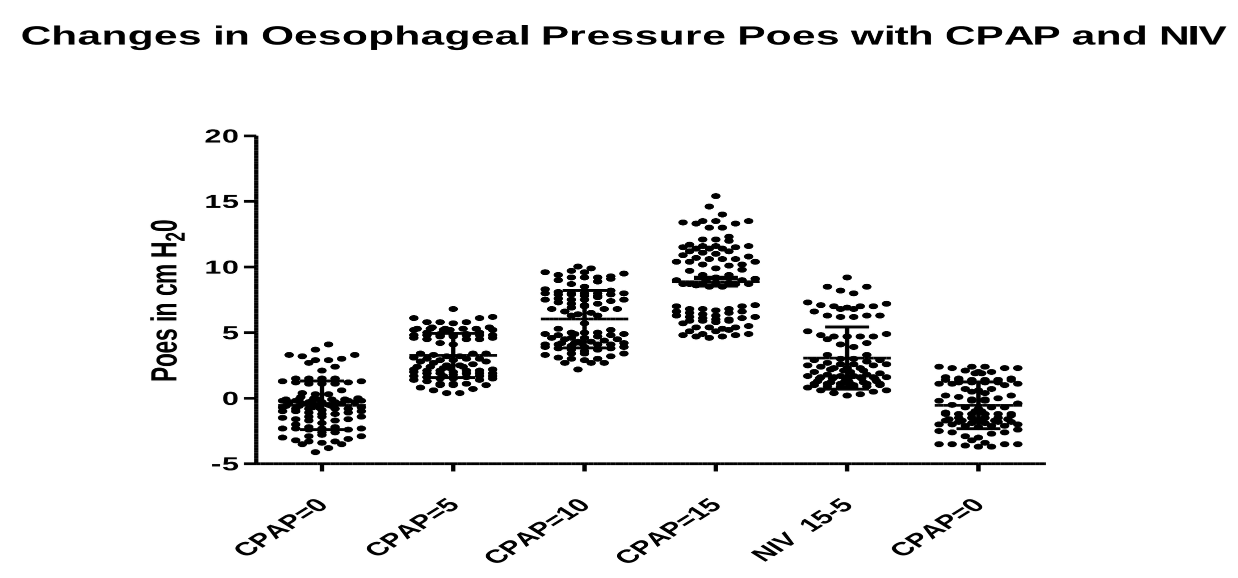
Data was analysed using Prism version 5.

Results

The mouth Pressure (Pmo) was lower than the setting for CPAP on the NIPPY3 ventilator P<0.001

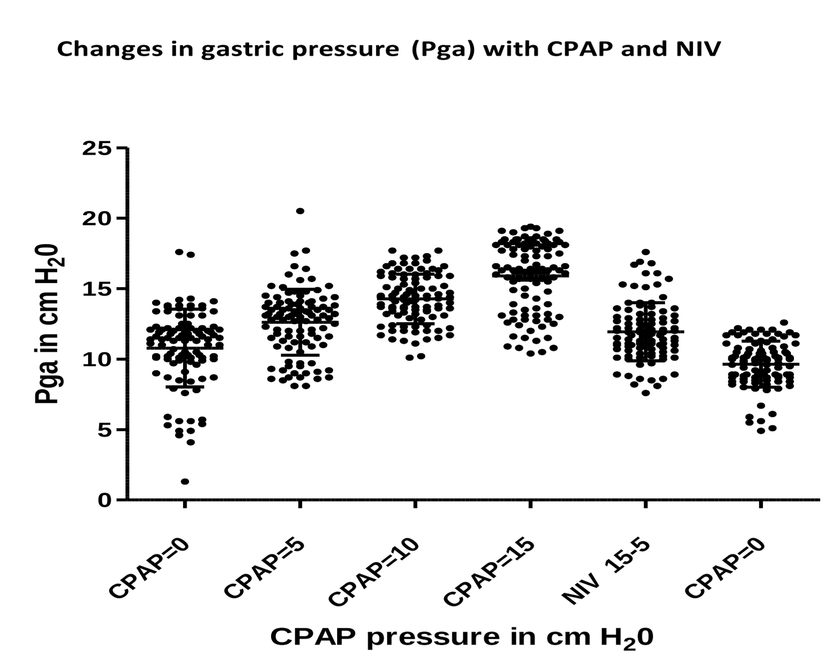


Poes rises with increasing CPAP and falls as expiratory pressure falls P<0.001

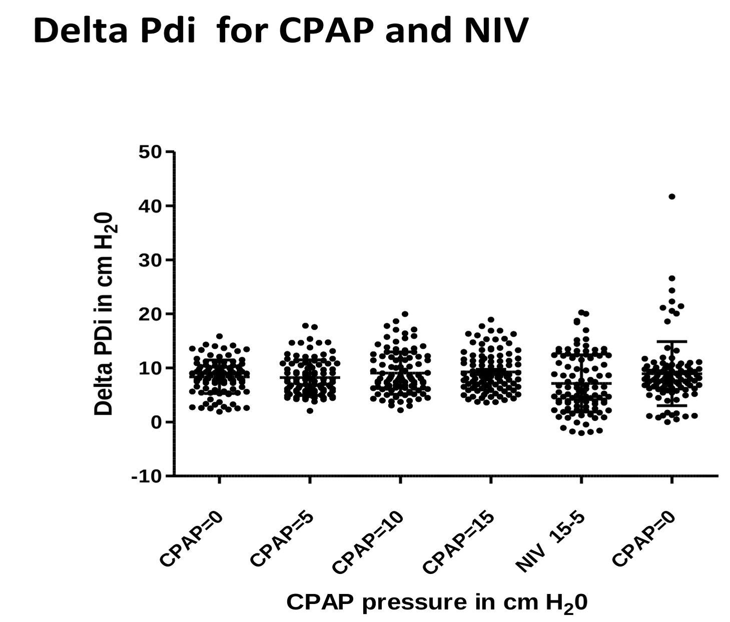


No significant change between Poes at beginning and end of experiment

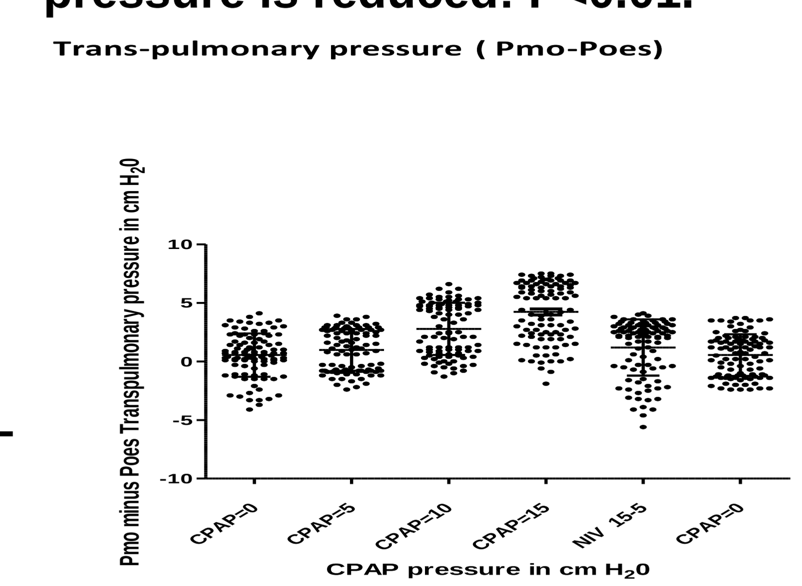
Pga rises with increasing CPAP and falls with NIV It is lower at the end of the study than at the beginning: 10—8.9cmH_2O; P<0.01.



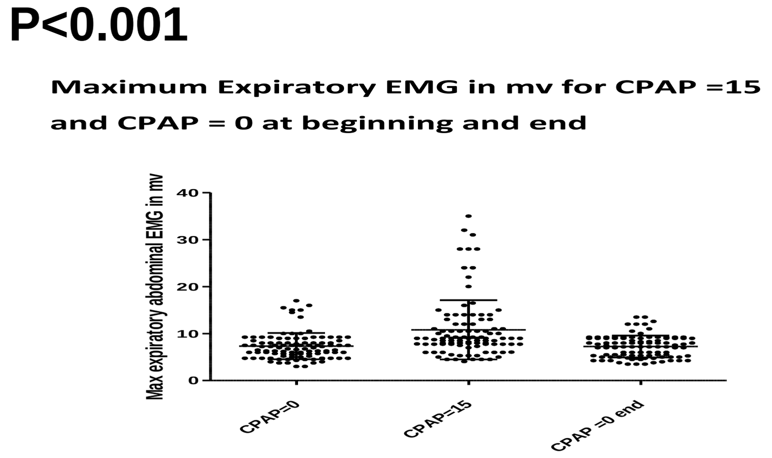
∆Pdi, as a measure of inspiratory work, falls when CPAP at 15cmH_2O changes to NIV at 15/5cmH_2O: P<0.001.



Trans-pulmonary pressure in expiration (Poes-Pga) rises with increasing CPAP of >5cmH_2O and falls when the expiratory pressure is reduced: P<0.01.



Abdominal expiratory muscle EMG rises with CPAP of 15cmH_2O and falls when CPAP falls: P<0.001



Conclusions

Increasing CPAP leads to an increase in mouth pressure (Pmo), oesophageal pressure (Poes), and gastric pressure (Pga) with a decrease in ∆Pdi when CPAP at 15cmH_2O changes to NIV with a lower expiratory pressure of 5cmH_2O reducing the work of breathing.

Mouth pressure is always lower than the setting on the CPAP machine due to leakage.

We have previously shown that although mouth pressure and oesophageal pressure stabilise rapidly after CPAP pressure is applied, gastric pressure takes longer to stabilise but we allowed for this by giving time for pressure stabilisation. (1)

Increasing CPAP leads to an increase in trans-pulmonary pressure which may lead to air trapping. Abdominal expiratory muscle activity increases when CPAP = 15cmH_2O and may assist expiration. This is similar to changes reported by EJM Campbell (2) in expiratory muscles with increasing expiratory load in 1957.

Pga falls between the beginning and end of the study, but abdominal wall EMG is unchanged suggesting that abdominal wall relaxation is not the cause, though changes in gastric or diaphragm tone might cause this(3).

Abdominal wall EMG increase may show the point at which CPAP leading to air trapping is countered by increased expiratory muscle activity and provide a non invasive method for assessing this.

References

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3. M K Polkey, Y Luo, S Hamnegard et al. Functional magnetic Stimulation of the Abdominal muscles in humans. (Am J Respir. Crit Care Med;1999; 160:513-522.