

# A new system for generating adjustable PEEP with high-flow nasal cannula oxygen therapy



## INTRODUCTION

- High-flow nasal cannula oxygen therapy (HFNC) is an essential respiratory support for patients with acute respiratory failure.[1]
- Physiological effects of HFNC are, [2]
  - ✓Reducing inspiratory effort: washout effect
  - ✗Oxygenation: positive end-expiratory pressure (PEEP).
- Patients requiring PEEP will,
  - Have treatment failure with HFNC
  - Converted to CPAP/NPPV, losing washout effect

## OBJECTIVES

- To develop a system that generates clinically relevant and adjustable PEEP while retaining the CO<sub>2</sub> washout effect of HFNC.
- Innovate a system to apply PEEP with HFNC.
  - Examine the ability of the new system to produce PEEP while retaining the CO<sub>2</sub> washout effect using a respiratory model.

## METHOD

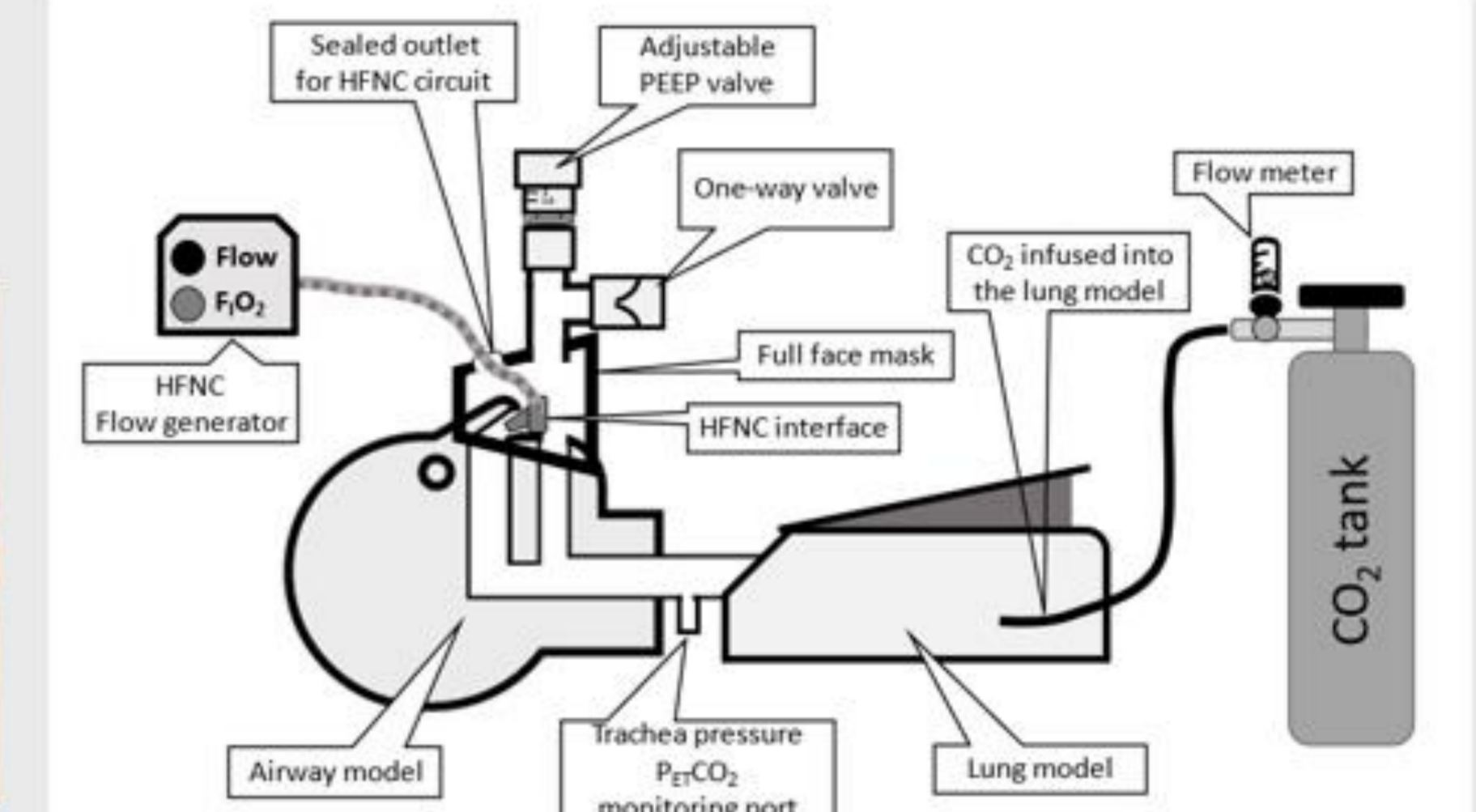


Figure 1. Innovated system (HFNC-P)

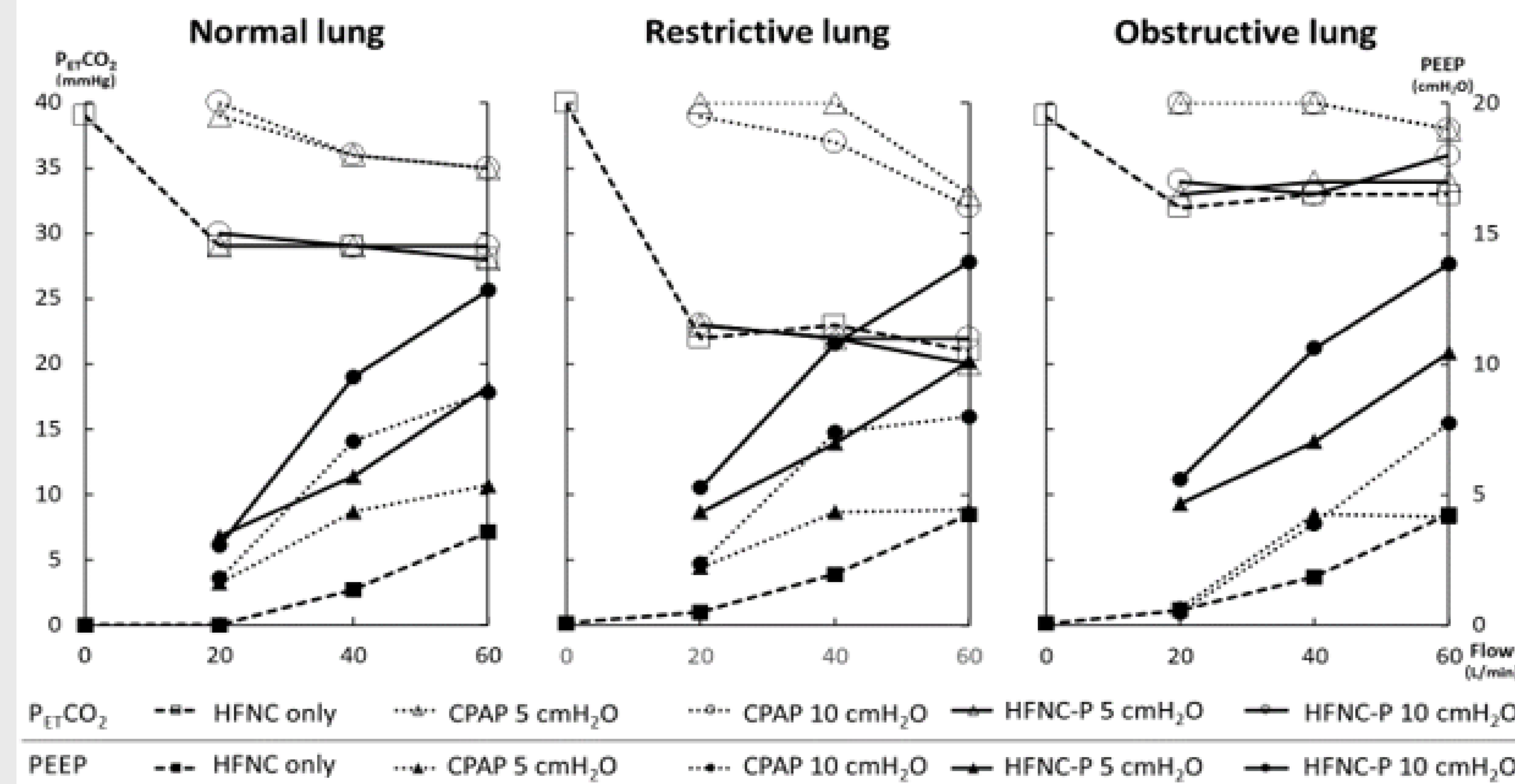
Figure 2. 3D printed life size airway model

Figure 3. Experiment system

- **HFNC:** HFNC (Optiflow, Fisher & Paykel, New Zealand) with flow rates of 20, 40, and 60 L/min.
- **CPAP:** A full-face mask (FMMD1001, c-ventec, Japan) with a PEEP valve set to 5 or 10 cmH<sub>2</sub>O
- **HFNC-P:** HFNC combined with a full-face mask (FMMD1001) and a PEEP valve set to 5 or 10 cmH<sub>2</sub>O (Figure 1)
- **Respiratory model:** A life-size airway model (Figure 2) and connected it to a Training and Test Lung (TTL, Michigan Instruments, United States of America) (Figure 3)

## RESULTS

- **Normal lung**
  - Compliance 50 mL/cmH<sub>2</sub>O
  - Resistance 5 cmH<sub>2</sub>O/L/sec
  - Vt 500 ml, RR 14 /min
- **Restrictive lung**
  - Compliance 20 mL/cmH<sub>2</sub>O
  - Resistance 5 cmH<sub>2</sub>O/L/sec
  - Vt 300 ml, RR 25 /min
- **Obstructive lung**
  - Compliance 80 mL/cmH<sub>2</sub>O
  - Resistance 20 cmH<sub>2</sub>O/L/sec
  - Vt 700 ml, RR 10 /min

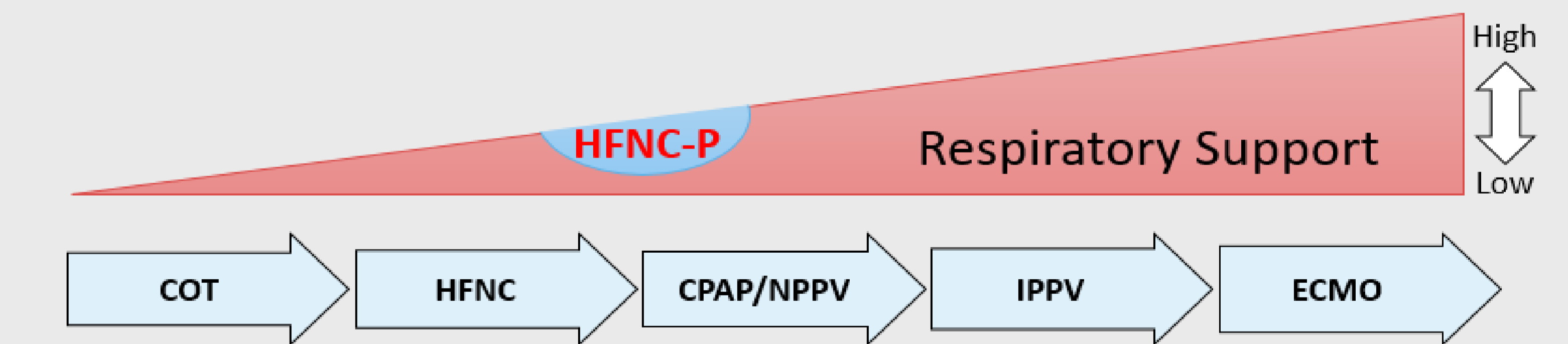


- **Washout effect**
  - HFNC-P reduced P<sub>ET</sub>CO<sub>2</sub> as same as HFNC while CPAP did not
- **Generated PEEP**
  - HFNC-P generated PEEP as much as CPAP and was adjustable with PEEP valve

## CONCLUSION

HFNC-P system, which consists of an HFNC, a full-face mask, and a PEEP valve, can produce a clinically relevant and adjustable PEEP while retaining the CO<sub>2</sub> washout effect.

HFNC-P may have possibility to compliment the lack of respiratory support between HFNC and CPAP/NPPV



## AUTHORS

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## CONTACT INFORMATION

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## ACKNOWLEDGEMENTS

None

## CONFLICT OF INTEREST

Authors (Y. Onodera, T. Hayasaka, M. Nakane) along with Dr. K. Kawamae (Specially Appointed Hospital Director, Ota-Nishinouchi Hospital, Fukushima, Japan) and c-ventec (Tokyo, Japan) jointly filed a patent application for HFNC-P.  
 (A patent application for HFNC-P has been filed in Japan under Application No. 2022-124563)

## REFERENCES

1. Grasselli G, Calfee CS, Camporota L, Poole D, Amato MBP, Antonelli M, Arabi YM, Baronecchi F, Bellier JR, Bellani G et al: ESICM guidelines on acute respiratory distress syndrome: definition, phenotyping and respiratory support strategies. *Intensive care medicine* 2023, 49(7):727-759.
2. Onodera Y, Akimoto R, Suzuki H, Okada M, Nakane M, Kawamae K: A high-flow nasal cannula system with relatively low flow effectively washes out CO<sub>2</sub> from the anatomical dead space in a sophisticated respiratory model made by a 3D printer. *Intensive Care Med* 2018, 6(1):7.

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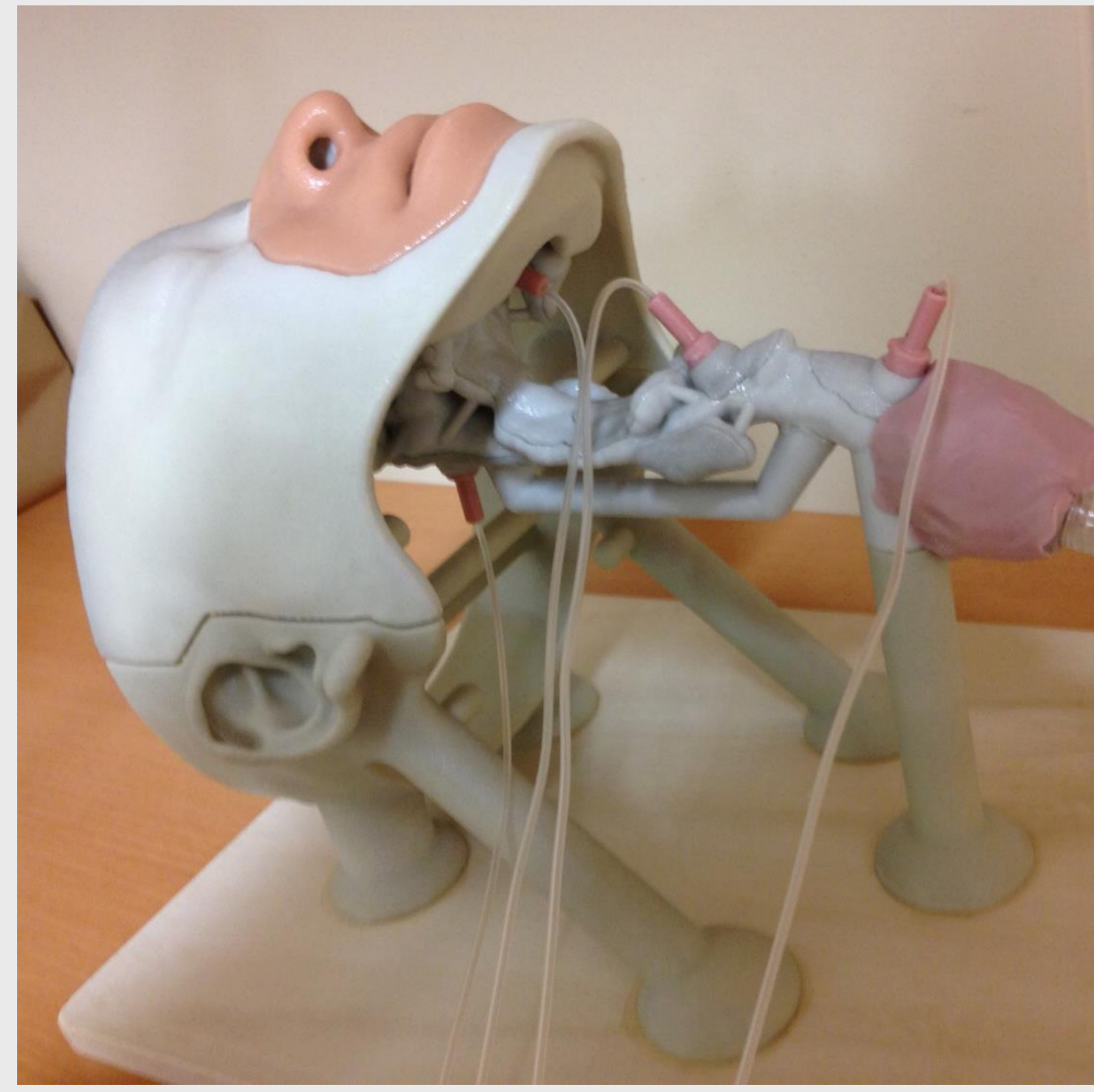


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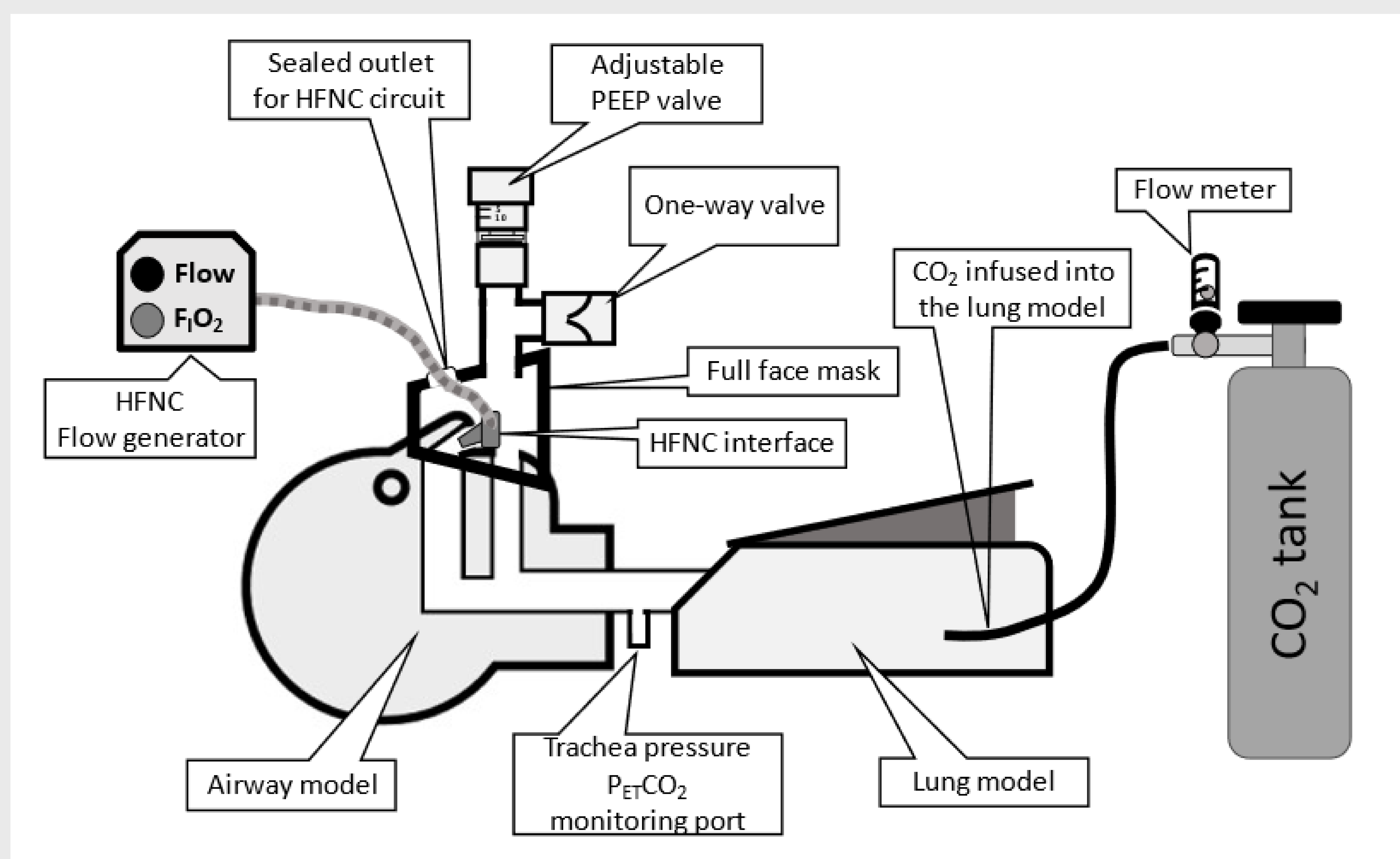


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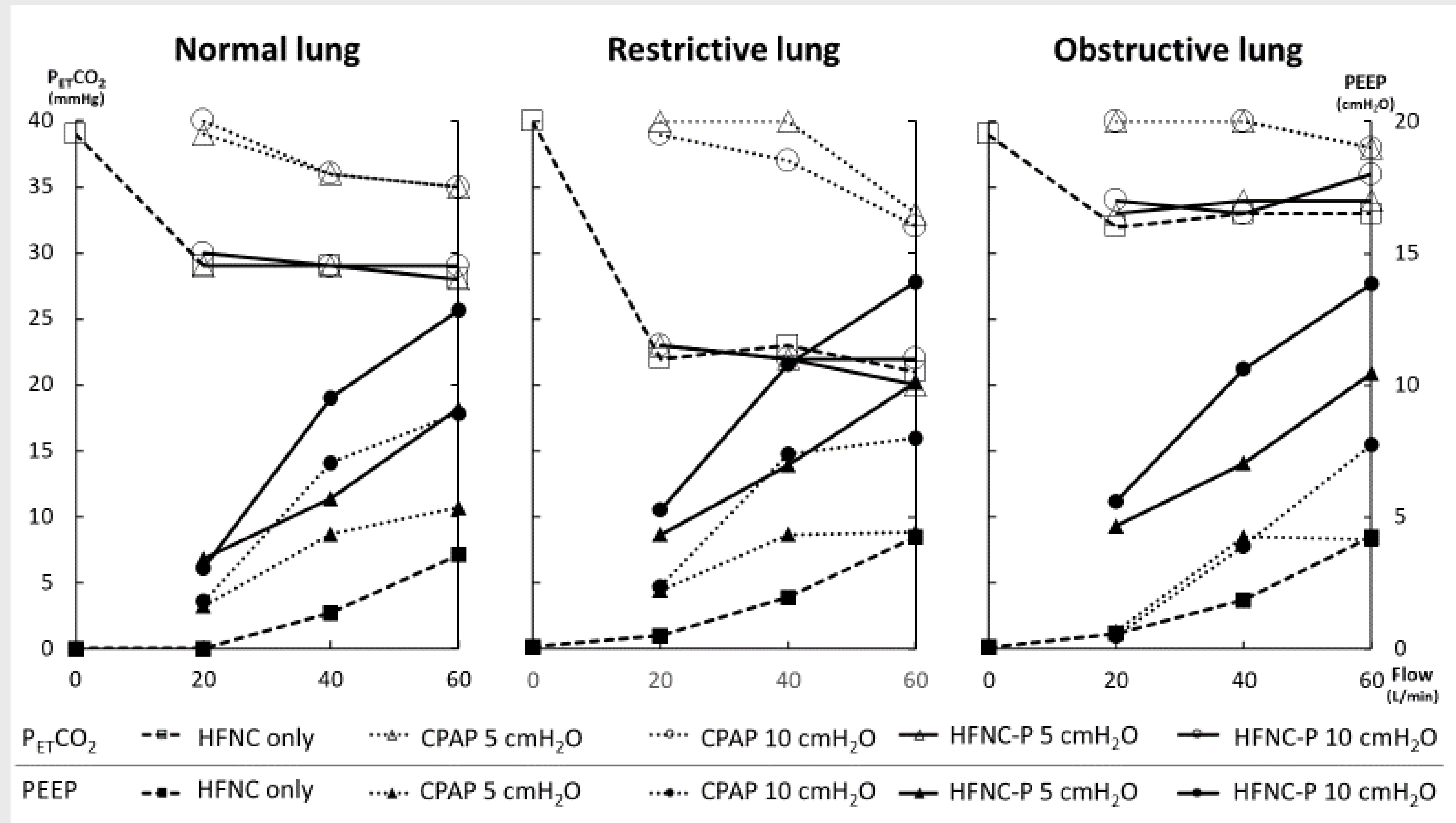
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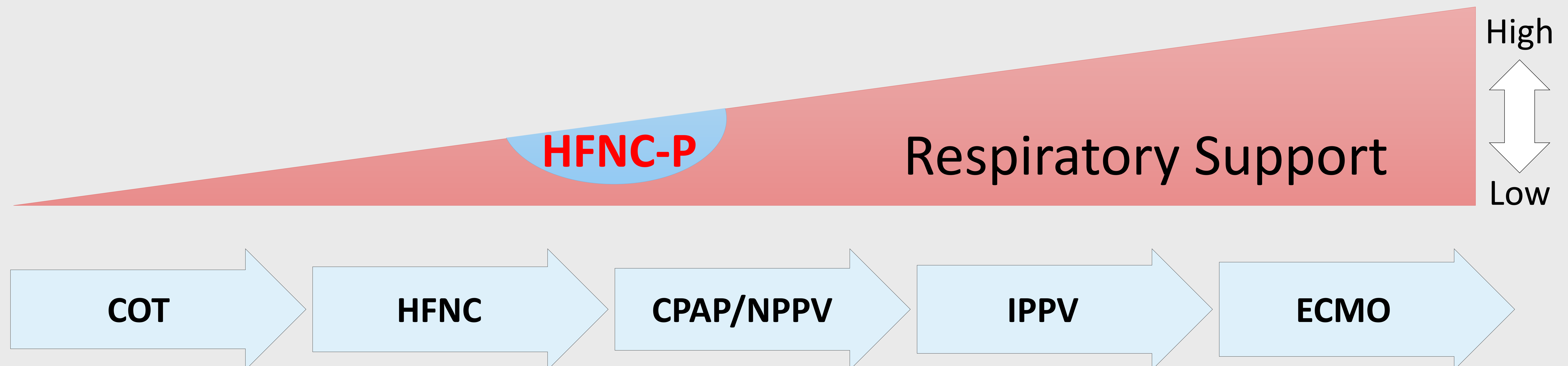
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