

# Optimizing ventilation through a cuffed narrow bore catheter (CNBC) using expiratory ventilation assistance (EVA): an animal study

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## Introduction

EVA has been proposed as a ventilation principle to allow sufficient gas exchange through small lumen cannulas or catheters [1]. The principle of EVA can be applied by the Ventrain, a flow-regulated, manually operated ejector ventilator capable of assisting expiration by jet-flow generated suction (Dolphys Medical, Eindhoven, The Netherlands) [2] [fig. 1A-C]. The optimal ventilation settings for EVA have not yet been determined. Therefore we evaluated the effect of different ventilation frequencies on the efficiency of EVA through a cuffed narrow bore catheter (CNBC) designed to be used in elective cases [3] [fig. 2A+B].

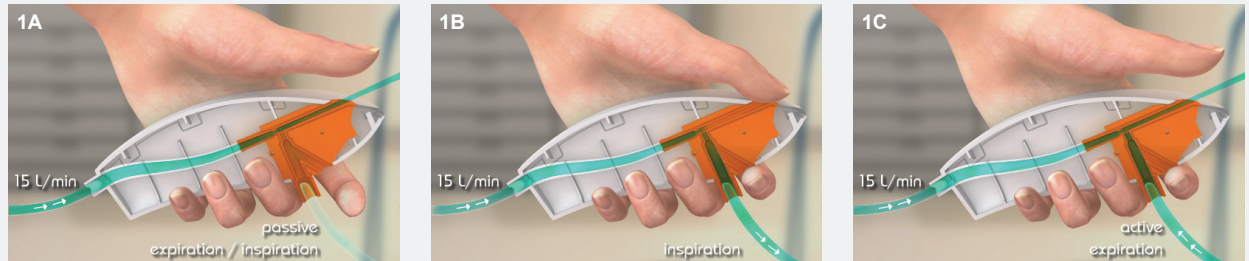


Fig. 1: Use of the Ventrain: 1A: equilibration (device not active) 1B: inspiration 1C: active (assisted) expiration



Fig. 2A: The 40 cm long cuffed narrow bore catheter (CNBC) has a 2.5 mm inner diameter (ID) ventilation lumen (blue Luer lock with metal stylet inside) and a separate pressure monitoring channel (white Luer lock). The arrow indicates the side opening of the pressure monitoring channel distally of the cuff.

2B: The inflated cuff ensures axial alignment of the opening of the 2.5 mm ID ventilation lumen.

## Material and Methods

After approval by the local Animal Welfare Committee six pigs (38-45 kg) were anaesthetized, intubated and normoventilated by intermittent positive pressure ventilation at an  $\text{FiO}_2$  of 0.4. Monitoring lines were placed. After baseline recordings the CNBC was inserted through the endotracheal tube. The Ventrain, connected to an oxygen flowmeter set to 15 L/min, was used to apply EVA. The pigs were ventilated for up to 30 minutes in a random order at ventilation frequencies of 15, 30, and 60 cycles/min with an I:E-ratio of about 1:1 with the endexpiratory endotracheal pressure kept between 0 and 5 mbar. After a washout period of at least 30 min the next experiment was started. At fixed intervals blood samples were collected. Descriptive statistical analysis of the data was performed.

## Results

Data are presented as median [range]. The minute volume required for normoventilation prior to the experiments was 6.9 [4.8-8.0] L/min.

	cycles / min	baseline	5 min	10 min	15 min	20 min	25 min	30 min
PaO <sub>2</sub> (mm Hg)	15	157 [92-174]	498 [390-549]	464 [424-539]	443 [375-507]	478 [397-542]	442 [346-513]	439 [367-504]
	30	150 [98-175]	431 [416-556]	456 [298-521]	462 [356-538]	455 [371-518]	464 [383-487]	457 [394-521]
	60	153 [96-160]	458 [312-514]	432 [265-513]	434 [326-508]	472 [359-530]	420 [344-502]	424 [354-503]
PaCO <sub>2</sub> (mm Hg)	15	40 [39-41]	34 [28-37]	33 [30-35]	32 [27-36]	32 [28-34]	30 [26-36]	32 [28-38]
	30	41 [37-43]	38 [36-42]	40 [33-46]	40 [34-46]	38 [34-46]	36 [32-46]	37 [32-47]
	60	42 [39-44]	48 [39-60]	49 [38-70]	53 [39-71]	55 [40-74]	51 [41-77]	55 [42-77]

## Conclusion

When using flow-controlled EVA through the 40 cm long, 2.5 mm ID CNBC, a ventilation frequency of 15 cycles/min achieved better CO<sub>2</sub>-removal compared to higher frequencies. Efficient gas exchange through this CNBC offers new possibilities for clinical practice.

## References

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- Hamaekers A, Borg P, Enk D: *Br J Anaesth* 2012; 108: 1017-21
- Enk, D: Patent application (10 2009 013 205.8), *German Patent Office*, 17.3.2009

## Acknowledgements

Fig. 1A-C taken from an instructional animation ([www.ventrain.com](http://www.ventrain.com)) by courtesy of Dolphys Medical. Fig. 2A+B provided by Sebastian Enk.

## Conflict of interests

Dietmar Enk is the inventor of the Ventrain and receives royalty payments from Dolphys Medical.

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