

## **VENTRAIN®, what's new?**

Alexander R. Schmidt, MD. Department of Anaesthesia, University Hospital Zurich, Switzerland

An unexpected difficult airway can develop to a worst-case scenario: The 'can't intubate - can't ventilate' situation (CICV). Although this situation is very rare, a recent review reported 75 CICV of 179 difficult airway cases (42%)<sup>1</sup>. In a CICV the transtracheal access is the recommended way to enable oxygenation of the patient. Either the needle-catheter technique or the surgical (large bore tube) approach can be performed, depending on availability of equipment, skills and training.

Traditionally with the needle-catheter technique, oxygenation was maintained with high pressure jet ventilation. Various case reports have shown the risks of conventional high pressure jet ventilation through a transtracheal catheter/cannula such as air trapping, pulmonary hyperinflation resulting in barotrauma, pneumothorax<sup>2-6</sup>. Therefore conventional jet ventilation is contraindicated in conditions with a complete or partially obstructed upper airway.

Several years ago a new ventilation device allowing active inspiration and expiration through a transtracheal airway catheter has become available on the market. The Ventrain® (Dolphys Medical, Eindhoven, The Netherlands) is a single-use, handheld manually controlled device driven by an external pressurized oxygen source<sup>7, 8</sup>. The new possibility of active expiration by suction is based on the Bernoulli principle<sup>9, 10</sup> and enables ventilation (oxygenation and decarboxylation) through a transtracheal catheter in patients with a pending, partial or complete upper airway obstruction.

Besides the classic transtracheal catheters other orally inserted airway devices, such as airway exchange catheters or small paediatric tubes can be used with Ventrain®. It has been shown that an airway exchange catheter (100 cm in length, 3.0 mm internal diameter) used with Ventrain® achieves adequate minute volume (around 7.36 litre min<sup>-1</sup>) in a simulated obstructed airway model<sup>11</sup>. A case report also reported the successful use of Ventrain® with an airway exchange catheter (Cook Medical, 65 cm in length and 3.0 mm internal diameter) in an elective setting with a partly obstructed airway in an adult patient<sup>12</sup>. A further case report from Sweden describes the successful

application of the Ventrain® device after multiple tracheal puncture attempts in a CICV situation with an obese patient (BMI 36). They even reported that blood clots from the trachea were suctioned into the Ventrain® device after a few cycles of ventilation; however this did not compromise ventilation<sup>13</sup>.

Unfortunately Ventrain®'s performance is dependent on the degree of the airway obstruction. The less the obstruction the worst is the performance. Enk et al. presented a study at the Difficult Airway Society Meeting 2012 showing that Ventrain® failed in sufficiently oxygenating and ventilating the open airway<sup>14</sup>. The development of an orally inserted cuffed jet ventilation catheter allowed sufficient oxygenation and ventilation and could be a solution to this problem<sup>15, 16</sup>.

Last but not least a recent study by Marsland et al compared Ventrain® and Manujet® in an obstructed airway model and found that both devices were able to obtain rapid re-oxygenation, but that the Ventrain® was superior regarding the peak airway pressures (16 vs 40 cm H<sub>2</sub>O), expiratory minute volume (4.7 vs 0.1 litre min<sup>-1</sup>), and end-protocol pH (7.34 vs 7.01). In all Ventrain® allowed sufficient ventilation at low airway pressures, whereas Manujet® caused hypoventilation with a considerable higher risk of barotrauma in an obstructed airway<sup>17</sup>.

Schmidt et al. used the Ventrain® emergency ventilation device with different oxygen sources to study their impact on the performance of Ventrain®. They found that different oxygen sources have different driving pressure resulting in lower tidal volumes than those described by the manufacturer<sup>18</sup>. This shows that depending on the indication Ventrain® also works with low pressure sources. In another study they investigated the feasibility and reliability of a respiratory function monitor (RFM) to monitor tidal volumes applied by the Ventrain®. The RFM was found to reliably measure tidal volumes after a simple mathematical correction process of the software<sup>19</sup>. An adapted version of the device could allow monitoring ventilation in order to minimize the risk of complications such as hyperinflation or occurrence of atelectasis due to too long expiration.

Conclusion: Ventrain® designed for emergency ventilation via a transtracheal catheter shows great ventilation performance and could even be used in selected elective ventilation settings with a

pending, partial or complete upper airway obstruction. Monitoring of tidal volumes may increase safety of the device and therefore further developments should be pursued. In the future other applications such as active expiration in patients with a fulminant status asthmaticus and others may be of interest.

#### References:

1. Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW. Management of the difficult airway: a closed claims analysis. *Anesthesiology* 2005; **103**:33–9.
2. Craft TM, Chambers PH, Ward ME and Goat VA. Two cases of barotrauma associated with transtracheal jet ventilation. *British journal of anaesthesia* 1990; **64**: 524-527.
3. Cook TM, Bigwood B and Cranshaw J. A complication of transtracheal jet ventilation and use of the Aintree intubation catheter during airway resuscitation. *Anaesthesia* 2006; **61**: 692-697.
4. Cook TM, Woodall N, Harper J and Benger J. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency departments. *British journal of anaesthesia* 2011; **106**: 632-642.
5. Kiyama S, Koyama K, Takahashi J and Fukushima K. Tension pneumothorax resulting in cardiac arrest during emergency tracheotomy under transtracheal jet ventilation. *Journal of anaesthesia* 1991; **5**: 427-430.
6. Hardy MJ, Huard C and Lundblad TC. Bilateral tension pneumothorax during jet ventilation: a case report. *AANA journal* 2000; **68**: 241-244.
7. Hamaekers AE, Borg PA and Enk D. Ventrain®: an ejector ventilator for emergency use. *British journal of anaesthesia* 2012; **108**: 1017-1021.
8. Borg PA, Hamaekers AE, Lacko M, Jansen J and Enk D. Ventrain® for ventilation of the lungs. *British journal of anaesthesia* 2012; **109**: 833-834
9. Hamaekers AE, Gotz T, Borg PA and Enk D. Achieving an adequate minute volume through a 2 mm transtracheal catheter in simulated upper airway obstruction using a modified industrial ejector. *British journal of anaesthesia* 2010; **104**: 382-386.
10. Hamaekers AE, Borg PA, Gotz T and Enk D. Ventilation through a small-bore catheter: optimizing expiratory ventilation assistance. *British journal of anaesthesia* 2011; **106**: 403-409.
11. Esther M. Dias, Ankie E.W. Hamaekers, Pieter A.J. Borg, Dietmar Enk. Adequate minute volume ventilation through a 100 cm long, 3 mm inner diameter airway exchange catheter by expiratory ventilation assistance (EVA). Poster presentation ESA congress 2012
12. Micheal Kalkoff. Ventilation through a small-bore intubating catheter using Ventrain® in an elective procedure. Published in British Journal of Anaesthesia on December 2012
13. Nellgård P. Ventrain® in a case of can't intubate can't ventilate situation. Case report presented at ESA 2013

14. T. van der Beek, A. Hamaekers, D. Enk. Efficiency and safety of applying expiratory ventilation assistance (EVA) through a jet ventilation catheter with a cuff in an open and sealed airway: an animal study. Abstract presentation Difficult Airway Society (DAS) congress 2012.
15. Tim van der Beek, Ankie Hamaekers, Dietmar Enk. Optimizing ventilation through a cuffed narrow bore catheter (CNBC) using expiratory ventilation assistance (EVA): an animal study. Poster presentation ESA congress 2013
16. Dietmar Enk, Sebastian Enk. Small Lumen Ventilation through a Cuffed Jet Ventilation Catheter: Efficiency and Safety. Poster presentation SAM congress 2012
17. Tzeng Y, Marsland C. Percutaneous transtracheal ventilation in an obstructed airway model in post-apnoeic sheep. Br J Anaesth. 2014 Jun 30
18. AR Schmidt, K Ruetzler, T Haas, A Schmitz, M Weiss. Impact of oxygen source on performance of the Ventrain® emergency ventilation device in an in-vitro lung model setting. Poster presented at the ESPA Congress 2013.
19. AR Schmidt, K Ruetzler, T Haas, A Schmitz, M Weiss. Monitoring inspiratory and expiratory tidal volumes in the Ventrain® emergency ventilation device. Poster presented at the ESPA Congress 2013.