Tracheostomy, Airflow and Weaning: Key Factors and Considerations

Tracheostomy, Airflow and the Work of Breathing

The effects of a tracheostomy tube on the overall work of breathing can be multifactorial and potentially opposing. It has been suggested that the presence of a tracheostomy tube may reduce the extrathoracic dead space and reduce upper airway resistance.[1] Conversely, the very presence of a tracheostomy tube in the upper airway can increase the work of breathing due to the increased resistance imposed by the smaller internal diameter of the tracheostomy tube compared to that of the native upper airway.[2]

Airflow through the tracheostomy tube greatly depends on tube size; larger tubes have greater airflow and lower resistance, which acts to decrease the work of breathing.

In addition resistive load can be reduced in a cuffed tube by deflating the cuff. An immediate advantage of cuff deflation is that it reduces the overall work of breathing by allowing airflow around the tracheostomy tube.[3] The passage of air both through the lumen of the tube and around the tube acts to decrease airway resistance and thus reduce the work of breathing.[3] As mentioned below in more detail, the work of Hussey and Bishop indicates that the collapsed cuff itself can greatly impact airflow, suggesting that the shape and volume of the cuff, when deflated, can influence the work of breathing.[4] Overall, the reduction in resistive load, along with an improvement in upper airway muscle function and coordination has supported the concept that cuff deflation can be one of the most important factors in enhancing ventilatory weaning success.

Tracheostomy, Airflow and Fenestration

Fenestration of the outer cannula, in conjunction with a fenestrated inner cannula, allows for upward airflow through the vocal cords and facilitates patient speech. While it seems logical that fenestration would reduce the work of breathing, surprisingly little research has been done in this area.

In 1996, Hussey and Bishop investigated the pressure required to move gas through a model airway for both fenestrated and non-fenestrated tubes.[4] As predicted, tubes with fenestrations reduced the work of breathing compared to non-fenestrated tubes with the cuff deflated. Interestingly, the authors noted that when they tested a cuffless No. 8 tube, the required inspiratory pressures remained below 1 cm of water at all flow rates. These findings suggest that the majority of the observed resistance to airflow for the cuffed tubes was due to the deflated cuff. The authors indicated that these results suggest that a lower profile cuff would reduce resistance and thus reduce the work of breathing. In light of their findings, the authors concluded that, in an average-sized trachea, the presence of a tracheostomy tube significantly increases the work of breathing and that much of this increase is due to the resistance provided by a deflated, high-volume, low-pressure cuff.

While evidence suggests that a fenestrated tube can reduce the work of breathing, the use of a fenestrated tube can also create problems, especially if the tube does not fit the patient's airway well or if the fenestration itself is not properly positioned.[5] In addition to these concerns, the fenestration itself can produce localized irritation of the tracheal wall that results in granuloma formation around the opening. If this tissue growth protrudes into the lumen of the tracheostomy tube, it can partially occlude the tube and thus reduce airflow through the tube.[6] Granuloma intrusion into the fenestration can also make it harder to remove the tube for downsizing or during weaning. Related to these concerns, Shrivastava et al. demonstrated that patients with fenestrated tubes had a longer average weaning duration (12 days vs. 7 days) and a higher rate of complications (56% vs. 16%) than patients with non-fenestrated tubes.[7] In this study, the specific complications of granuloma formation, stuck tube, and tracheostomy obstruction were approximately seven times more likely with a fenestrated tube.[7]

Summary

There are many factors that influence upper airway airflow in tracheostomy patients, including tube size, cuff size and shape, use of a fenestrated vs. a non-fenestrated tube and patient anatomy. While larger tube sizes reduce resistance to airflow through the tube, larger tubes take up more of the upper airway and increase resistance to airflow around the tube. Even when deflated, the tube cuff can introduce resistance to airflow around the tube, and cuffs that deflate more completely and closer to the tube help increase airflow around the tube. The use of a fenestrated tube can increase airflow and reduce the work of breathing. Each of these factors can play a role in successfully weaning patients.

References

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