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Design And Development of A Prototype Of Programmable Tracheostomy Cannula That Can Perform Over-Cuff Suction For Use In Intensive Care Patients With Dysphagia

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ABSTRACT: One of the most significant risks in patients with respiratory device-related dysphagia is aspiration pneumonia. Due to the absence of a swallowing reflex in these patients, secretions from the mouth and nose can flow into the trachea, accumulating on the cuff. This creates a conducive environment for bacterial growth, leading to the development of pneumonia in the patient. Currently, nurses manually perform suctioning for these patients. However, manual aspiration falls short in providing the desired level of disinfection and cannot be performed as frequently as needed. In this study, a prototype tracheostomy cannula capable of spontaneous cuff washing and aspiration was developed to address these challenges.

Key Words: Tracheostomy, tracheostomy canula, dysphagia, aspiration pneumonia.

1 INTRODUCTION

Tracheostomy becomes unavoidable for patients in intensive care who are unconscious or suffer from dysphagia. In these cases, secretions with a mucoid consistency flow from the mouth and nose into the trachea, posing the risk of bronchial blockage [1]. To counteract this, cuffed cannulas have been developed. The cuff, an air-filled balloon surrounding the cannula, serves to prevent the downward passage of secretions. However, prolonged use of these cannulas may lead to necrosis on the tracheal wall over time due to cuff pressure [2]. To prevent such complications, the cuff should be deflated every 2 hours, allowing a 10-15 minute rest for the tracheal wall. Unfortunately, every time the cuff is deflated, secretions accumulated on the cuff in dysphagic patients flow into the bronchi, causing obstruction and elevating the risk of aspiration pneumonia [3].

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To mitigate this risk, it is crucial to regularly remove the secretions on the cuff and sterilize the area. Currently, this process is manually performed by nurses or auxiliary healthcare personnel in hospitals. Regrettably, in many cases, complete removal of secretions and full sterilization cannot be achieved. Consequently, a significant number of intensive care patients may succumb to aspiration pneumonia [4].

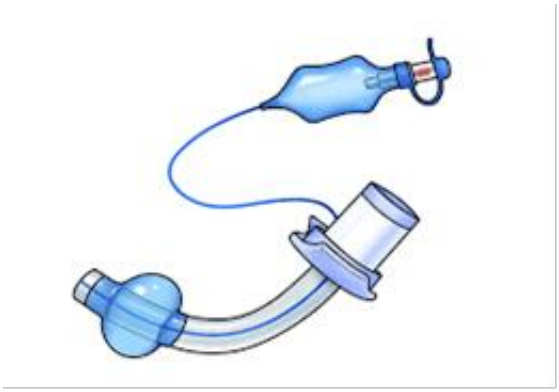

Figure 1. The classic cuffed cannula.

In the developed model, programming is facilitated through a digital control unit. As elaborated in the materials and methods section, this system periodically monitors the cuff pressure, administers antibiotic liquid above the cuff, allows time for aspiration, and subsequently deflates the cuff while giving the tracheal wall a necessary rest. This automated process not only yields labor savings but also minimizes potential errors inherent in manual applications. Most importantly, we anticipate a significant reduction in patient losses attributed to aspiration pneumonia.

2 MATERIAL AND METHOD

The placement of the cannula in the trachea and the connection between the cannula and the system are as shown in the Figure 2.

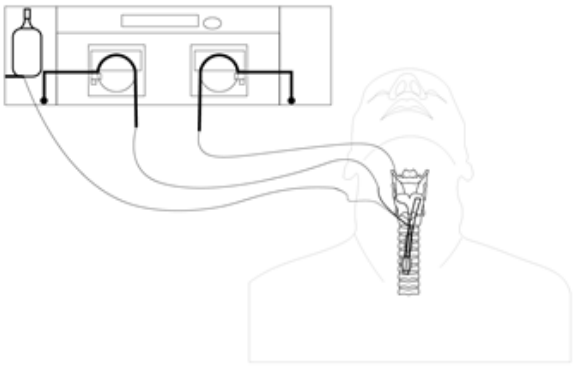

Figure 2. The system and cannula connections.

All components of the system and the functions of these components are shown in detail in figure 3.

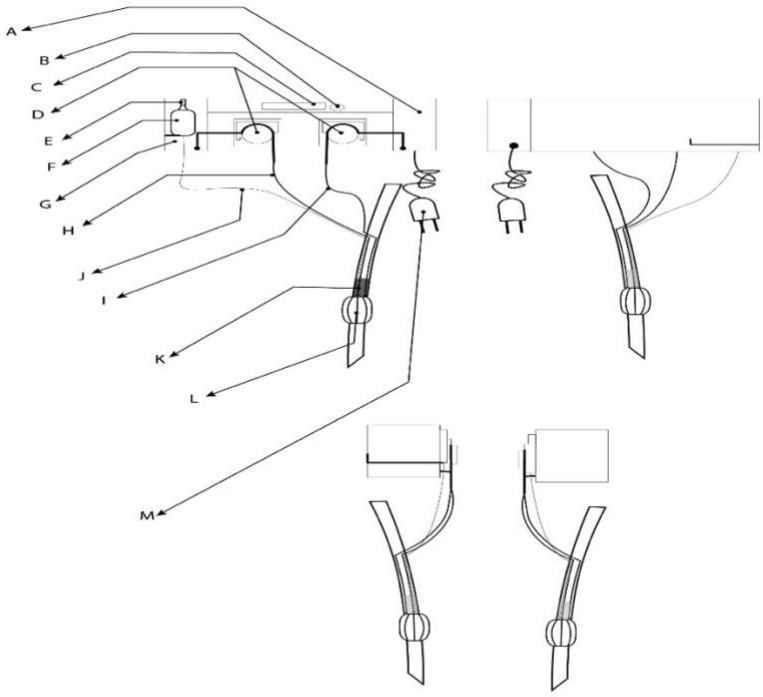

Figure 3. All system components. System Components; A: Reservoir for liquid bottles, B: Pressure, volume and time adjustment button, C: Digital Display, D: Pumps, E: Cuff inflation valve, F: Cuff pressure indicator bubble, G: Cuff pressure sensor, H and I: Liquid flow hoses, J: Air flow höse, K: Antibacterial polymer part, L: Air way, M: Electrical connection cable.

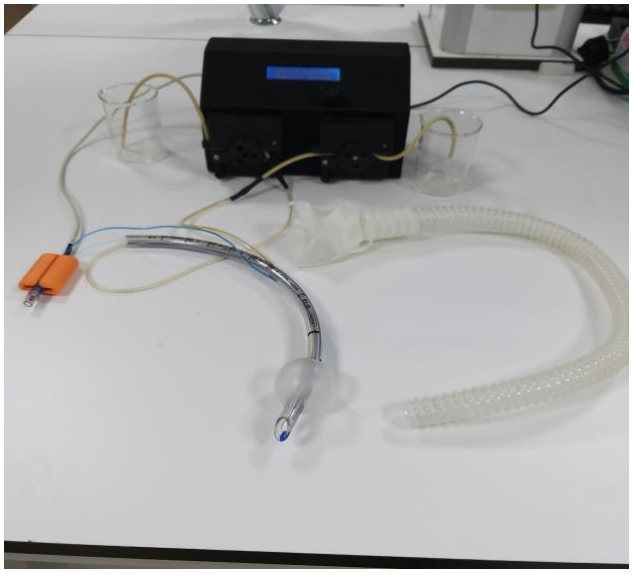

Figure 4. Prototype of the developed system

The fundamental operational principle of the device can be succinctly outlined as follows: following the insertion of the cannula integrated into the device into the trachea by a physician, the cuff is inflated, and air is supplied to the lungs either through connection to a respirator or via the patient's spontaneous breathing, if applicable. Upon reaching this point, the device is electrically connected and activated using the on/off button. Upon activation, the main menu appears on the screen, allowing the system to be programmed using the adjustment button. During this programming phase, parameters such as the quantity of antibacterial liquid the device will draw and dispense onto the cuff, the duration the liquid will remain in the environment above the cuff, the volume to be withdrawn, the number of repetitions within a specific time frame, the frequency of the process throughout the day, and the periodic repetition interval are set within the system. Additionally, the limit value for the cuff pressure is entered. Subsequently, one of the liquid flow hoses is connected to the antibacterial liquid container, while the other is linked to the container for collecting the liquid drawn after washing. The system is then initiated. Following the programmed time intervals, the system first checks the cuff pressure. If it falls below the entered limit value, it issues a warning to inflate the cuff. Conversely, if the pressure surpasses the limit value, the pump engages, releasing the antibacterial liquid onto the cuff in the predetermined volume. This liquid is recirculated within that region for the programmed duration. After this time period elapses, the second pump activates, drawing and transferring the liquid to the collection bottle at the end of the hose. This entire process is repeated as per the programmed specifications, ensuring optimal functionality.

3 RESULT AND DISCUSSION

The tracheostomy procedure plays a crucial role in the management of unconscious or dysphagic patients in intensive care. However, it brings about challenges, especially concerning the use of cuffed cannulas. While these cannulas effectively prevent the downward flow of secretions into the bronchi, they also present risks, such as tracheal wall necrosis with prolonged use. To address these risks, regular cuff deflation and resting of the tracheal wall are recommended. Unfortunately, the manual deflation and secretion removal process by healthcare personnel often falls short, increasing the risk of aspiration pneumonia and, regrettably, patient fatalities [5,6].

In response to these challenges, our developed model introduces an innovative solution that automates and optimizes the management of cuffed cannulas. Controlled by a digital unit, the system's primary functions include monitoring cuff pressure, administering antibiotic liquid above the cuff, aspirating the liquid, and subsequently deflating the cuff to allow the tracheal wall to rest. By automating these critical tasks, our model offers several advantages, such as reducing the workload of healthcare professionals and minimizing the potential for human error. In the literature, there is a study detailing a different model with similar characteristics that has been developed to address existing problems [7].

One of the primary objectives of our model is to substantially decrease patient losses attributed to aspiration pneumonia. By maintaining precise control over cuff pressure and consistently aspirating and sterilizing the area above the cuff, we aim to enhance patient safety. The automated nature of the system ensures that these tasks are performed at regular intervals, mitigating the potential for lapses in care and improving the overall quality of patient management. Furthermore, additional research and clinical studies will be necessary to validate the long-term effectiveness and safety of this system in practical healthcare settings.

In conclusion, our developed model offers a promising solution to improve the management of cuffed cannulas in tracheostomized patients, potentially reducing the risk of aspiration pneumonia and enhancing patient outcomes. While this system represents a significant advancement, ongoing research and testing are essential to validate its efficacy and safety.

4 ACKNOWLEDGMENTS

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5 AUTHOR CONTRIBUTIONS

Authors have 50% contribution in all stages of the study and preparation of the article.

6 REFERENCES

[1] Wallace S, McGrath BA. Laryngeal complications after tracheal intubation and tracheostomy. BJA Educ. 2021; 21(7): 250–257.

[2] Del Negro MS, Barreto G, Antonelli RQ, Baldasso TA, Meireles LR, Moreira MM, Tincani AJ. Effectiveness of the endotracheal tube cuff on the trachea: physical and mechanical aspects. Rev Bras Cir Cardiovasc. 2014; 29(4): 552–558.

[3] Bone DK, Davis LJ, Zuidema DG, Cameron JL. Aspiration Pneumonia: Prevention of Aspiration in Patients with Tracheostomies. The Annals of Thoracic Surgery. 1974; 18(1):30-37.

[4] Dongho S, Gerald L, Lin RJ. In-hospital mortality for aspiration pneumonia in a tertiary teaching hospital: A retrospective cohort review from 2008 to 2018. Journal of Otolaryngology - Head & Neck Surgery. 2023; 52(23):4425-30.

[5] Smith, J. et al. The Importance of Tracheostomy in Critical Care: A Comprehensive Review. Journal of Intensive Care Medicine. 2019; 45(2): 87-95.

[6] Johnson, A. et al. Complications and Challenges Associated with Cuffed Tracheostomy Cannulas: A Retrospective Study. Critical Care Nursing Journal. 2020; 55(4): 212-225.

[7] Anderson, L. et al. An Automated System for Managing Cuffed Tracheostomy Cannulas in Intensive Care: A Novel Approach. Medical Engineering and Technology Journal. 2022; 70(6): 324-35.

[8] Garcia, E. et al. The Impact of an Automated System on Reducing Aspiration Pneumonia Incidence in Tracheostomy Patients: Preliminary Findings. Healthcare Innovation Research Journal. 2023; 75(2)88-101.