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Effectiveness of Modified Small Volume Jet Nebulizer on Aerosol Treatment in Small Children

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Background:
Small children may experience major problems during aerosol treatments because of the penetration of irregular particles to the lower lung and the small tidal volume of each breath if the same adult nebulizer is used. Using the adult nebulizer produces a huge number of particles at a high speed which small children are unable to absorb. The presentation will describe application of applying evidence based practice guidelines adapted from care of adults with respiratory conditions to design a modified small volume jet nebulizer for small children. The design was based on adding 6 inches of corrugated tube between the nebulizer and face mask thus creating a reservoir to tap and slow down the speed of the particle produced to better meet the health needs of small children with respiratory ailments.

Methods:
The standard practice of using adult sized nebulizers with small children resulted in inefficient and poor quality treatments for critical respiratory conditions that could threaten the lives of small children. Three successive clinical researches and one simulation study working with engineer were completed in reviewing use of nebulizers, testing the design change, and measuring the clinical outcomes.

All of the three clinical studies used a quasi-experimental, pretest-post test design to investigate the effectiveness in acceptance behavior, physical properties, and clinical outcomes in 238 children aged 1-5 years with bronchospasm. The experimental group received aerosolized bronchodilation by using the modified device while the control group used the conventional adult sized one. Before and after 15 minutes of each aerosolized bronchodilation, researcher assessed acceptance behavior, physical properties (dead volume, duration for aerosolization), and clinical outcomes (oxygen saturation, respiratory rate, and degree of wheezing). The acceptance behavior group was analyzed and tested for the significant differences by using independent t-test, the difference changes of the outcomes: oxygen saturation, respiratory rate, and degree of wheezing were analyzed and tested by using Mann-Whitney U test while the difference changes in heart rate were analyzed and tested by using ANCOVA.

One study was done by using ANSYS® computer program for engineer to stimulate the flow dynamic of aerosolized particles created by the 2 devices to foretell the speed, direction, and behavior of the flow. By creating the MESH computer model of the 2 devices, researcher specified different conditions concerning with the amount of oxygen used (6-8 liters/min.), respiratory rate (30-40 times/min.), and tidal volume (80-120 ml.) into the program. The flow simulations based on different conditions were created to investigate the effectiveness of the design change in slowing down the speed, behavior of the flow and how it could reserve the volume.

Results:
The results from 3 clinical studies revealed that experimental group reported a higher acceptance behavior ($Z = -1.999^*$), higher mean score of change in oxygen saturation and degree of wheezing, greater reduction in respiratory rate per minute than control group with statistical difference ($p<.05$) which accepted the hypothesis. However, the rest clinical outcome which was heart rate per minute showed no significant difference ($p > .05$) due to action of bronchodilator that made heart rate increased in both groups. Longer time to evaluate the clinical outcomes was needed to explore the better outcomes while the physical properties were not different.

The results from simulation study revealed that the undulations of the corrugated tube were the important parts those changed the direction of the aerosol flow from laminar to turbulent flow which could slow

down the speed of the aerosol produced up to 33.9% (mean speed at the end which closed to the patient's nose equaled to 0.37 m/sec. via modified nebulizer vs 0.54 m/sec. via conventional one while opened oxygen flow 6-8 liters/min., RR = 30-40 times/min. TV = 80-100 ml. with error less than 5.13%) The corrugated tube itself acted like a reservoir that could reserve around 80 ml. of the volume waiting for the small children to breath in which accepted the hypothesis.

Conclusions:
All of the 4 research studies proved that the use of a modified small volume jet nebulizer designed to accommodate small children demonstrated improved treatment outcomes for this age group. Using the redesigned aerosol treatment in small children was considered more effective because it could reserve and slow down the aerosol production for better spread over the reservoir. More effective aerosol bronchodilation could improve breathing efficiency and effectiveness of small children and improve clinical outcomes while the physical properties were the same.

Title:
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Abstract Summary:
This applying evidence based practice study is a reviewed paper of 4 research studies: 3 clinical and 1 simulation study to investigate the effectiveness of modified small volume jet nebulizer to improve the aerosol treatment in small children age 1-5 years.

Content Outline:

1. Introduction
    1. Major problems during aerosol treatment in small children is the lost of most aerosol particles to the atmosphere due to irregular pattern of breathing, low tidal volume, crying and grunting during treatment
    2. Small volume jet nebulizer used is the same as in the adult that produces aerosol at high speed and high volume than small children can absorb.
    3. Small volume jet nebulizer was modified by adding 6 inches of corrugated tube between nebulizer and face mask to accommodate more effectiveness in slow down the speed and act as a reservoir to reserve more volume in the system ready for small children to breath in.
2. Body
    1. Four successive researched: 3 clinical and 1 simulation research were reviewed.
    2. Sample of 283 Asthmatic children age 1-5 year were recruited in 3 clinical studies. Using quasi-experiment, pretest-post test design to investigate 3 outcomes:
        1. Acceptance behavior
        2. Clinical outcomes: oxygen saturation, RR, HR, degree of wheezing
        3. Physical properties: dead volume, duration of treatment
    3. Before and after 15 minutes of each treatment, researcher assessed: acceptance behavior, physical properties, and clinical outcomes
    4. One simulation was done by using ANSYS computer program for engineering to simulate the flow dynamic of aerosolized particles to foretell the speed, direction, and behavior of the flow.
    5. Acceptance behavior, mean score of change in clinical outcomes, and physical properties were analyzed and test for significant different by using independent t-test, Mann-Whitney U test, ANCOVA were used in these 4 studies.
    6. 3 clinical studies revealed that experimental group reported a higher acceptance behavior, higher mean score of change in oxygen saturation and degree of wheezing, greater reduction in respiratory rate per minute than control group with statistical difference ($p<.05$) while physical properties still the same.

7. Simulation study proved that the redesign device could slow down the speed and reserve more volume in the system.

3. Conclusion
    1. The used of modified small volume jet nebulizer might be the good choice for aerosol treatment in small children because it could reserve, slow down the aerosol production to make them well spread all over the reservoir and ready for small children to breath in order to get good clinical outcomes.

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