A COMPARISON OF THE THERAPEUTIC EFFECTIVENESS AND ACCEPTANCE OF CONVENTIONAL POSTURAL DRAINAGE AND PERCUSSION, INTRAPULMONARY PERCUSSIVE VENTILATION AND HIGH FREQUENCY CHEST WALL COMPRESSION IN HOSPITALIZED PATIENTS WITH CYSTIC FIBROSIS

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By

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ABSTRACT

A significant clinical manifestation of cystic fibrosis is abnormally abundant and viscous bronchial secretions. This leads to obstruction of bronchi in the lungs and predisposes the individual to chronic pulmonary infections. Bronchopulmonary hygiene is an essential part of the care of a patient with cystic fibrosis in order to enhance mucociliary clearance. Currently, several modalities of therapy are available, including high frequency chest wall compressions (HFCC), intrapulmonary percussive ventilation (IPV) and conventional postural drainage and percussion (PD&P). This study was designed to directly compare the sputum produced with HFCC, IPV and PD&P.

Twenty-seven hospitalized patients were recruited for the study. Each patient received two consecutive days of each form of therapy in random order. All therapies were delivered three times a day for thirty minutes. Any sputum produced during the treatment time was expectorated and collected. Sputum was collected for a total of sixty minutes: fifteen minutes before the treatment during aerosol delivery, during the thirty minute treatment and for fifteen minutes post therapy. Sputum expectorated during each session was weighed wet and then dried and weighed again. The mean wet weight for HFCC was 4.95 (4.00) grams, IPV was 6.77 (5.77) grams and PD&P was 5.10 (5.56)

grams. The mean dry weight for HFCC was 0.25 (0.17) grams, IPV was 0.38 (0.44) grams and PD&P was 0.33 (0.27) grams. Mean weights were analyzed using ANOVA with repeated measures. The mean wet sputum weight results approached statistical significance with p=0.050. The mean dry sputum weight results were not statistically significant with a p=0.140. Based on this study, it can be concluded that HFCC and IPV are at least as effective as conventional PD&P for the hospitalized patient with cystic fibrosis.

The participants were also asked to complete a questionnaire regarding their feelings about the comfort, convenience, ease of use and efficacy of each of the modalities. The majority of respondents felt IPV and PD&P were somewhat or very comfortable, while they were divided on the comfort of HFCC. Almost all participants felt the three therapies were convenient and easy to use. PD&P and IPV were considered more effective than HFCC. The results of this study suggest that each patient needs to determine the correct balance of comfort, convenience, ease and efficacy for themselves when selecting a bronchopulmonary hygiene modality.

Dedicated to all those afflicted with cystic fibrosis

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CHAPTER 1

INTRODUCTION

Background:

Cystic Fibrosis is a genetic abnormality of the exocrine glands. A significant clinical manifestation of cystic fibrosis is abnormally abundant and viscous bronchial secretions. This leads to the obstruction of bronchi in the lungs and predisposes the individual to chronic pulmonary infections which require frequent hospitalizations. As a part of daily cystic fibrosis care, bronchopulmonary hygiene is essential to enhance mucociliary clearance and to diminish the frequency of pulmonary complications. Currently, there are several modalities of bronchopulmonary hygiene available, including Conventional Postural Drainage and Percussion (PD&P), Intrapulmonary Percussive Ventilation (IPV), High Frequency Chest Wall Compressions (HFCC), the Flutter Valve, Positive Expiratory Pressure (PEP) and Forced Expiratory Techniques (FET).

Conventional PD&P has been used for many years. During the therapy, the caregivers use their hands to clap or percuss the patient's chest over all lung fields. The clapping motion produces sound waves which have the effect of loosening the retained

secretions. This clapping is performed while the patient is placed in twelve different body positions. These positions encourage the drainage of the loosened secretions into the larger airways through the effects of gravity. A mechanical percussor is sometimes used as a replacement for hand clapping. The use of a bronchodilator before the treatment relaxes any constricted bronchial muscles, opens up the airways and enhances secretion movement. Periods of vigorous coughing are encouraged between the positions and at the end of each treatment session to aid in secretion removal. Because conventional PD&P requires the assistance of a caregiver, patient compliance with twice daily therapy at home, each session being up to forty-five minutes in length, is sometimes compromised.

Both IPV and HFCC are self-administered, thus encouraging independent disease management. The use of the IPV device is thought to accomplish both bronchodilation, due to the albuterol nebulization, and percussion at the same time. The device utilizes a phasitron which acts as a sliding venturi to change the source gas into high frequency positive pressure pulsations. A bronchodilator can be aerosolized by the source gas to be delivered during the therapy. The pulsations theoretically reach the distal airways and cause the secretions to be loosened. Secretions are then removed by vigorous coughing during the treatment. The treatment sessions are twenty to thirty minutes in length.

The HFCC uses an inflatable vest to provide bronchopulmonary hygiene. This vest, which covers the entire torso, is made of a non-stretchable material. The vest is inflated and deflated at high frequencies. This action has a percussive effect on the chest. The treatment is divided into six five-minute intervals between which the patient is encouraged to cough vigorously to remove secretions. The frequency of the vest

oscillations is adjusted such that sputum expectoration is optimized. The patient usually receives bronchodilator therapy before the treatment. The HFCC treatment aims to move secretions to the large airways where they are more easily expectorated.

The effectiveness of bronchopulmonary hygiene is determined by several different methods. The amount of sputum expectorated is an objective measure of effectiveness that can be determined at the bedside. If more sputum is expectorated during the treatment, the therapy has been effective. As a result of secretion removal, oxygen saturation may improve, as may pulmonary function measurements, specifically FVC, FEV_1 and $FEF_{25\%-75\%}$. The chest x-ray may also show less consolidation and/or atelectasis if the bronchopulmonary hygiene is effective. The outcome of any effective bronchopulmonary hygiene treatment is an improved clinical picture of the patient, evidenced by fewer IV antibiotic days and fewer days in the hospital.

Significance and Purpose of the study:

Although each bronchopulmonary hygiene therapy has been shown to be safe and effective, no study has yet directly compared these treatment modalities in patients with cystic fibrosis. The purpose of this study was to compare the therapeutic effectiveness and acceptance of conventional Postural Drainage and Percussion, High Frequency Chest Wall Percussion and Intrapulmonary Percussive Ventilation in promoting bronchial hygiene in hospitalized patients with cystic fibrosis. This valuable information will allow for better therapeutic decisions regarding the care of the cystic fibrosis patient in the future.

Research questions:

The research questions that were addressed in this study include:

1. Was there a significant difference in the wet and dry weights of sputum produced between the three modalities?

2. What were the participants' opinions regarding convenience, comfort and effectiveness for each of the three modalities in the hospital and for use at home?

3. Was there a difference in the participants' perception of the effectiveness of the therapies and the actual amount of sputum produced?

4. Were the participants in the study representative of the cystic fibrosis population?

These questions were answered through the analysis of data collected previously from a study conducted at Columbus Children's Hospital . The protocol was developed by Ohio State University senior respiratory therapy students in conjunction with Robert Castile, M.D., John Servick, RRT/RCP, Jill Tice, R.N., and Herbert Douce, RRT/RCP. Human subjects review approval was granted in December 1995 and data collection began in February 1996. In July 1997, twenty-seven patients had successfully completed the protocol. The data was analyzed by one of the students involved in the protocol development and data collection.

Definition of terms:

Bronchodilator - a drug that relaxes contractions of the smooth muscles of the bronchioles in order to improve ventilation.

Bronchopulmonary Hygiene - the use of any therapeutic modality designed to facilitate the removal of secretions from the lungs.

Expectoration - the removal of mucus or sputum form the lungs by coughing and spitting.

Flutter Valve - a hand-held device that creates a flutter as one exhales through it to loosen mucus for expectoration.

High Frequency Chest Wall Compressions (HFCC) - an inflatable vest that is inflated and deflated at high frequencies in order to move secretions to the large airways for expectoration.

Intrapulmonary Percussive Ventilation (IPV) - a device that delivers aerosolized medications simultaneously with internal vibrations via positive pressure to loosen mucus to be expectorated.

Positive Expiratory Pressure (PEP) - a hand-held device designed to produce resistance to exhalation in an effort to loosen mucus to be expectorated.

Postural Drainage and Percussion (PD&P) - involves patient positioning and clapping with cupped hands over specific areas on the chest to loosen and mobilize secretions to be expectorated.

Pulmonary Function Tests (PFT) - procedures used to evaluate a patient's respiratory functions.

CHAPTER 2

LITERATURE REVIEW

Introduction:

This review of the literature will provide the background necessary to assist the reader in understanding this study. The literature cited also helps to support the need for the study and to justify the methodology used in the study.

Literature Review:

Regular thrice daily bronchopulmonary hygiene is one of the mainstays of hospital treatment for patients with cystic fibrosis. Desmond et al evaluated the immediate and long-term effects of conventional PD&P in eight children with cystic fibrosis. Patients who did not receive PD&P for a three week period had a deterioration in lung function, as demonstrated by a 10% decrease in FEV_1, that was reversible with the renewal of regular PD&P.[1] Reisman et al conducted a study involving eight subjects to determine the role of conventional PD&P in cystic fibrosis care. They found subjects who discontinued PD&P and used forced expiratory technique alone had a significantly greater decline in

pulmonary function tests, specifically a -10.2% predicted/year decline in $FEF_{25\%-75\%}$ over the three year study period. They concluded PD&P should remain a standard component of therapy in cystic fibrosis.[2] A meta-analysis of thirty-five past studies conducted by Thomas et al determined standard PD&P resulted in significantly greater sputum expectoration, measured in grams, as well as an increase in FEV_1 when compared to no treatment.[3] These studies support conventional PD&P as a valuable and effective technique of bronchial hygiene in patients with cystic fibrosis.

In a study conducted by Konstan et al, the Flutter device was compared to coughing and to PD&P in eighteen patients with cystic fibrosis. This study was conducted on an outpatient basis. Wet sputum weights and sputum pellet weights were measured and used as an indicator of efficacy. Expectorated sputum was collected during the fifteen minute treatment session. The mean wet sputum weight for the cough session was 2.6 grams +\- 2.3 grams and the sputum pellet weight was 2.0 grams +\- 2.1 grams. For the PD&P sessions, the mean wet weight was 2.1 grams +\- 2.1 grams and the sputum pellet weight was 1.6 +\-1.8 grams. The mean wet sputum weight for the Flutter was 11.0 +\- 8.0 grams and the sputum pellet weight was 8.9 +\- 7.8 grams. Based on these results, they concluded that the Flutter effectively facilitates the removal of secretions form the airways of patients with cystic fibrosis and that the Flutter is more effective than coughing and PD&P.[12]

Several other alternative techniques of chest physical therapy have been developed and investigated in an effort to help patients administer their own bronchial hygiene. Recent studies suggest that two devices designed to aid in the clearance of sputum from

the airways, IPV and HFCC, may be as effective or possibly more effective than PD&P. In a study involving nine outpatient cystic fibrosis patients, Natale et al compared sputum quantity expectorated between PD&P and IPV. This was a randomized crossover study which controlled for Albuterol nebulization. IPV was found to be as effective as standard aerosol and PD&P administration in enhancing sputum expectoration since there was no statistical difference in the quantity of sputum produced or in FEV_1.[4] Homnick et al compared IPV and conventional manual PD&P in sixteen patients with cystic fibrosis. The IPV study group's baseline FEV_1 was 70% predicted, +/-12%, and the PD&P group's baseline FEV_1 was 59% predicted, +/-12%. At the end of the six month study period, the IPV group's FEV_1 was 69% predicted, +/-14% and the PD&P group's FEV_1 was 59% predicted, +/-14%. The study concluded, based on the lack of change in FEV_1 measurements and patient satisfaction surveys, that IPV is as effective as standard aerosol and PD&P and that IPV was well accepted by the patients.[5]

Hansen et al tested the efficacy of HFCC in aiding mucus clearance for patients with cystic fibrosis. The sputum expectorated by five patients was collected and weighed during conventional PD&P and HFCC with frequencies between twelve and sixteen Hertz. Both modalities were studied for thirty treatment sessions. This study determined HFCC is more effective than standard PD&P, as shown by a statistically significant increase in the expectoration of mucus.[6] Another study conducted by Warwick et al determined the long-term effects of HFCC. Sixteen cystic fibrosis patients were studied for an average of twenty-two months. The therapy sessions were thirty minutes in length, consisting of six frequencies for five minutes each. They concluded that lung function, specifically FVC

and FEV_1 improved after HFCC treatment when compared with conventional bronchopulmonary hygiene.[7] Dasgupta et al studied sputum from eight cystic fibrosis patients and found that both rhDNase and high frequency oscillations produced a significant reduction in sputum spinnabilty, or thread forming ability, of up to 59%. Maximum reduction in spinnability (77%)was produced by combining rhDNase with high frequency oscillation.[8] Arens et al randomly assigned fifty patients with cystic fibrosis admitted for pulmonary exacerbation of symptoms and treatment with IV antibiotics to receive their in-hospital bronchopulmonary hygiene either by standard PD&P or HFCC. They collected and measured the amount of sputum expectorated with each thirty minute treatment and for the hour following each treatment session. The mean wet sputum weight for HFCC was 14.6+/-2.9 grams and the mean dry sputum weight was 1.4+/-0.4 grams. The mean wet sputum weight for PD&P was 6.0+/-1.8 grams and the mean dry sputum weight was 0.8+/-0.2 grams. They concluded, based on an increase in the FVC, FEV_1 and $FEF_{25\%-75\%}$ for both modalities and the lack of statistical difference in the sputum weights, that HFCC and PD&P were equally safe and effective.[9] Braggion et al studied the short-term effects of three different bronchopulmonary hygiene regimens (PD&P, PEP and HFCC) on sixteen patients with cystic fibrosis who were admitted for an acute pulmonary exacerbation. Two days of each therapy were randomly administered and a comparison of wet and dry sputum weights was made. Sputum collection occurred during each fifty minute treatment session as well as during the thirty minutes following the treatment. The wet sputum weight for HFCC was 22.92+/-12.36 g and the dry weight was 1.44+/-0.74 g. The wet weight for PD&P was 29.96+/-16.25 g and the dry weight

was 1.63+/-0.75 g. The wet weight for PEP was 26.13+/-12.28 g and the dry weight was 1.38+/-0.47 g. They concluded there is no difference in efficacy between the three tested modalities, based on the lack of statistically significant difference in wet and dry sputum weights.[10] Kluft et al also evaluated the effectiveness of HFCC in promoting the expectoration of secretions. They studied twenty-nine hospitalized cystic fibrosis patients who were randomized to receive either conventional PD&P or HFCC over two consecutive two day periods. Expectorated sputum was collected for the length of the treatment session and during the fifteen minutes following completion of the treatment. Wet and dry sputum weights were then measured. Wet weight for HFCC was 6.76 g and dry weight was 0.74 g. Wet weight for PD&P was 2.86 g and dry weight was 0.26 g. Significantly more sputum was expectorated, both in terms of wet and dry sputum weights, during HFCC. They concluded that HFCC is at least as effective as conventional bronchopulmonary hygiene therapy.[11]

Homnick et al also included a patient satisfaction survey in their study comparing IPV and PD&P. They surveyed the eight members of the IPV study group after completion of the trial. The questions asked about frequency of therapy, time spent on therapy, reliance on others and comfort of IPV. In general, the participants felt they performed chest physiotherapy more with IVP, spent less time on therapy, relied less on others for therapy and they felt the therapy was relatively comfortable. All eight participants completing the survey said they would continue to use IPV after completion of the study if given the opportunity.[5]

CHAPTER 3

METHODS

Introduction:

The data analyzed was collected from an inpatient cross-over study that involved twenty-eight cystic fibrosis patients. The data was collected between February 1996 and July 1997 at Children's Hospital in Columbus, Ohio. Patients were admitted for IV antibiotics and intensive bronchopulmonary hygiene because of a pulmonary exacerbation of their disease process, as determined by the attending and/or admitting physician.

Research Design:

In order to compare the efficacy of the three airway clearance techniques (PD&P, IPV and HFCC), each of the three modalities were delivered in a standard manner, three times a day for two days over a total of six consecutive days. The order in which the two days of each type of therapy was delivered was randomized. All sputum expectorated by the patients during therapy sessions was collected and weighed both wet and after drying.

The effectiveness of the different treatment modalities was assessed by comparing the two day total wet and dry sputum weights.

Subject Selection

Before the patient was accepted into the study, he or she had to meet the inclusion criteria detailed below:

Inclusion Criteria:

1. Documented diagnosis of cystic fibrosis (two sweat chloride tests greater than 60mEq/L)
2. Clinical evidence of chronic pulmonary disease (PFTs, CXR)
3. Able to provide informed consent
4. Twelve years of age or older
5. Able to tolerate thirty minutes of each modality
6. Able to follow all directions listed in protocol
7. Able to effectively expectorate mucus secretions

Exclusion criteria:

1. Pneumothorax, hemoptysis, congestive heart failure or rib fracture in the last six months
2. Pregnancy

Informed consent was obtained from the patient or from the patient's parent if under the age of eighteen.

Methods:

The order in which the three treatment modalities were applied was randomized by randomizing the treatment sequence in a controlled manner. The participants were randomly assigned to one of the following possible sequences:

Group Sequence #1: PD&P, HFCC, IPV n=4

Group Sequence #2: HFCC, IPV, PD&P n=4

Group Sequence #3: IPV, PD&P, HFCC n=4

Group Sequence #4: PD&P, IPV, HFCC n=4

Group Sequence #5: HFCC, PD&P, IPV n=4

Group Sequence #6: IPV, HFCC, PD&P n=4

Each group received the first treatment modality three times per day on two consecutive days, with the next two treatment modalities administered in the same manner. The use of six sequences was intended to equalize any effect of the order in which the treatment modalities were applied. See Table 3.1.

INCLUSION/ EXCLUSION CRITERIA MET	THERAPY #1		THERAPY #2		THERAPY #3	
ADMISSION	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
INFORMED CONSENT OBTAINED						

Table 3.1. Study design

The protocol was completed on six consecutive days, beginning within forty-eight hours of admission. Fifteen minutes prior to each treatment modality, each patient received an Albuterol aerosol (2.5 mg in 3 cc normal saline). Each thirty minute treatment period for all modalities consisted of a total of twenty-four minutes of therapy and six minutes of directed coughing. The therapies were performed and sputum was collected by respiratory therapists and nurses actively involved in the protocol.

PD&P Protocol: The Standard Nursing Procedure at Columbus Children's Hospital, i.e. Helping Hand.

An Albuterol aerosol was started fifteen minutes prior to the treatment. All twelve postural drainage positions were used. Four positions were percussed for two minutes each. This eight minutes of therapy was followed by two minutes of directed coughing. This pattern was repeated two more times for a total of thirty minutes. See Appendix A for details of the standard nursing procedure.

IPV Protocol: A Modification of Approved Columbus Children's Hospital Respiratory Care Protocol.

An Albuterol aerosol was started fifteen minutes prior to the treatment. This represents a change from usual therapeutic procedure wherein Albuterol and saline are given via the IPV device during the treatment. This change in the standard Columbus Children's Hospital protocol was made in order to standardize the time at which Albuterol was given for all three therapies. Eight minutes of the treatment were performed, followed by two minutes of directed coughing. This pattern was repeated two more times for a total of thirty minutes. The impact or frequency was adjusted for each patient based on comfort and chest movement. The therapy was delivered with the patient in a sitting position. See Appendix B for details of Columbus Children's Hospital approved standard protocol for IPV.

HFCC Protocol: A Modification of Approved Columbus Children's Hospital Respiratory Care Protocol.

An Albuterol aerosol was started fifteen minutes prior to the treatment. In order to standardize the amount of time the therapy and directed coughing were performed for each treatment, the study procedure differed from the standard protocol. Two frequencies were used for four minutes each followed by two minutes of directed coughing. This pattern was repeated two more times for a total of thirty minutes. The frequencies utilized were 6, 8, 14, 15, 18 and 19 Hz. The therapy was delivered with the patient in a sitting position. See Appendix C for details of Columbus Children's Hospital approved standard protocol for HFCC.

Sputum Collection Protocol:

During all forms of therapy, patients were directed to expectorate all mucus into pre-weighted cups for collection. Coughing was encouraged throughout all bronchopulmonary hygiene therapies, as this is an important step in mobilizing secretions. The therapist or nurse that performed the therapy facilitated coughing whenever the patient felt the necessity to cough. This was important especially during productive coughs to ensure the patient would expectorate rather than swallow the sputum.

Patients were instructed to expectorate into the sputum cups during the aerosol treatment as well as during the entire length of the bronchopulmonary hygiene therapy. Sputum collection also continued for fifteen minutes following the end of each treatment session, only when the patient felt the need to cough or clear secretions spontaneously. All sputum produced over the sixty minute period either by directed or spontaneous coughing was collected.

Sputum cups were heat resistant, as they were subject to a drying oven (65° C/150° F). In addition, the sputum cups were labeled with the patient's name, date of treatment, time of treatment and which therapy was used. Each cup was marked with the empty weight prior to use.

Wet weight of the sputum was measured after each modality by a respiratory therapist. The samples were then frozen at -20° C until transferred to a drying oven. Dry weight of the sputum was determined after the samples had been in the drying oven at 65° C for three days to ensure complete dryness. The balance used had a sensitivity of 0.00g.

Following completion of the treatment sequence, patients were asked to complete a written questionnaire (Appendix D) pertaining to the acceptance of each treatment modality. The questionaire was developed by a researcher involved with the protocol. The questionnaire evaluated patient opinions regarding the convenience, comfort and effectiveness of the three different forms of therapy as well as implications for outpatient therapy.

The protocol was developed by Ohio State University senior respiratory therapy students in conjunction with Robert Castile, M.D., John Servick, RRT/RCP, Jill Tice, R.N., and Herbert Douce, RRT/RCP. Human subjects review approval was granted in December 1995 and data collection began in February 1996. In July 1997, twenty-seven patients had successfully completed the protocol. The data was analyzed by one of the students involved in the protocol development and data collection.

Data Analysis:

Patient demographic information, including age, sex, height, weight and pulmonary function test results were compared to national statistics compiled by The Cystic Fibrosis Foundation.

Two day mean total wet sputum weights for each therapeutic modality was compared by analysis of variance with repeated measures. Two day mean total dry sputum weights for each therapeutic modality was compared in the same manner. Questionnaire responses were compiled and frequencies were tabulated for all the questions. Statistical significance was defined as an alpha level of less than 0.05.

CHAPTER 4

RESULTS

Introduction:

The research findings of this study are presented in four sections: first, the results of the statistical tests for difference in the wet and dry weights of sputum produced between the three modalities; second, the results of the participant survey regarding convenience, comfort and effectiveness of each of the three modalities; third, a comparison of the participants' perception of the effectiveness of the therapies and the actual amount of sputum produced; and last, the comparison of the participants in the study to the national demographic data compiled by The Cystic Fibrosis Foundation (CFF) [13].

Twenty-seven patients completed the protocol between February 1996 and July 1997. There was an even distribution of participants in each of the six treatment sequences. Five of twenty-seven participants were randomly assigned to the first treatment sequence (17.9%), five to the second, four to the third and fourth (14.3%) and five to the fifth and sixth treatment sequences.

Wet and Dry Sputum Weights:

The data were analyzed using SPSS 7.0 statistical software®. The mean wet and dry weight for each modality was calculated, and an ANOVA with repeated measures was performed for the means of both wet and dry weights. This statistical test was employed in order to test the difference between the three mean weights.

The mean wet weight for HFCC was 4.9454 grams with a standard deviation of 3.9975 grams. The IPV mean wet weight was 6.7711 grams with a standard deviation of 5.7683 grams. PD&P had a mean wet weight of 5.1036 grams, and a standard deviation of 5.5646 grams. This data were computed based on an n=27, since one participant did not complete the entire protocol due to discomfort experienced with one modality. The tests of with-in subjects effects were determined in order to assess the variability within the three modalities. The f-ratio was 3.179 and the level of significance was 0.050. See Table 4.1.

Modality	Mean (SD)	F-ratio	Level of significance
HFCC	4.95 (4.00)		
IPV	6.77 (5.77)		
PD&P	5.10 (5.56)		
		3.179	0.050

Table 4.1 Wet Sputum Weights (in grams) from three bronchopulmonary hygiene modalities.

The mean dry weight data was also analyzed in the same manner. The mean dry weight of sputum for HFCC is 0.2519 grams with a standard deviation of 0.1685 grams. IPV had a mean dry weight of 0.3845 grams, and a standard deviation of 0.4440 grams. The mean for PD&P was 0.3310 grams with a standard deviation of 0.2714 grams. These calculations were again based on an N=27. The f-ratio was computed to be 2.039 with a level of significance of 0.140. See Table 4.2.

Modality	Mean (SD)	F-ratio	Level of Significance
HFCC	0.25 (0.17)		
IPV	0.38 (0.44)		
PD&P	0.33 (0.27)		
		2.039	0.140

Table 4.2 Dry Sputum Weights (in grams) from three bronchopulmonary hygiene modalities.

General Perceptions of Therapy:

Twenty-four of the twenty-seven participants (89%) completed the questionnaire and rated the comfort, convenience, efficacy, and ease of therapy (Appendix D). Respondents used a five-point Likert-type scale with responses of extremely, very, somewhat, not very, and not at all to rate each modality independently. The detailed responses are presented in Table 4.3. For comfort of therapy, 88% of respondents rated PD&P, and 79% of respondents rated IPV as somewhat or more comfortable. There was

no apparent agreement among participants on the comfort of HFCC. Nearly an equal number of respondents rated HFCC as comfortable and as uncomfortable. For convenience of therapy, more than 90% of respondents indicated that HFCC and IPV were somewhat or more convenient; whereas, 75% rated PD&P as somewhat or more convenient. For treatment effectiveness, 71% considered PD&P, and 59% considered IPV as very or extremely effective; whereas, only 42% thought HFCC was as effective. Almost all participants rated all three modalities as easy to use.

How comfortable was each treatment?	Extremely	Very	Somewhat	Not Very	Not at all
HFCC	21	17	21	21	21
IPV	9	31	39	13	9
PD&P	21	29	38	8	4
How convenient was each treatment?	Extremely	Very	Somewhat	Not Very	Not at all
HFCC	26	35	30	4	3
IPV	21	33	38	8	0
PD&P	17	33	25	13	13
How effective was each treatment?	Extremely	Very	Somewhat	Not Very	Not at all
HFCC	17	25	38	17	4
IPV	13	46	29	13	0
PD&P	29	42	25	4	0
How easy was each treatment to use?	Extremely	Very	Somewhat	Not Very	Not at all
HFCC	42	29	29	0	0
IPV	25	46	25	4	0
PD&P	38	25	25	8	4

Table 4.3 Participant perceptions of three bronchopulmonary hygiene modalities (all data expressed as percentage of respondents).

The second part of the questionnaire consisted of four pairs of questions distinguishing most and least effective, comfortable, convenient, and preferable to use at home. Participants selected one modality that best answered each question. The detailed responses are presented in Table 4.4. In general, HFCC was not felt to clear much sputum and was not considered very comfortable, but it would be convenient to use at home.

However, an almost equal number would prefer it most as least to use in the home. IPV was felt to be the most convenient treatment to use at home; whereas, almost equal numbers would prefer or would not prefer it at home, thought it most or least effective or most or least comfortable. Only a few participants felt PD&P the least comfortable and the most convenient to use at home. Almost equal numbers of participants would prefer PD&P most or least to use at home and thought PD&P cleared the most and least sputum.

	HFCC	IPV	PD&P
With which treatment do you feel you cleared more sputum?	22	35	44
With which treatment do you feel you cleared the least sputum?	42	21	38
Which treatment do you feel is most comfortable to use?	30	30	39
Which treatment do you feel is least comfortable to use?	50	38	13
Which treatment do you think would be most convenient to use at home?	46	50	5
Which treatment do you think would be least convenient to use at home?	21	17	63
Which treatment would you most prefer to use at home?	42	29	29
Which treatment would you least prefer to use at home?	48	26	26

Table 4.4 Participant comparisons of three bronchopulmonary hygiene modalities (all data expressed as percentage of respondents).

Perceptions of Effectiveness and Sputum Weights

To compare participant perceptions of treatment effectiveness with actual effectiveness, sputum weights and percents of responses were ranked. A comparison of the ranks is shown in Table 4.5. HFCC cleared the least wet and dry sputum and was

considered the least effective. Although IPV produced the most wet and dry sputum, the participants felt that PD&P produced the most and that IPV produced less than PD&P.

Modality	Wet Sputum Weight	Dry Sputum Weight	Considered Most Effective	Considered Least Effective
HFCC	3 / 4.95 grams	3 / 0.25 grams	3 / 22%	1 / 42%
IPV	1 / 6.77 grams	1 / 0.38 grams	2 / 35%	3 / 21%
PD&P	2 / 5.10 grams	2 / 0.33 grams	1 / 44%	2 / 38%

Table 4.5 Ranked Percent of Responses for Effectiveness of Three Bronchopulmonary Hygiene Modalities.

Demographic Information:

A total of twenty-seven participants completed the program. Fifteen were males (57.7%), eleven were females (42.3%), and information was unavailable on one of the participants. This is similar to the findings of the Cystic Fibrosis Foundation, Patient Registry 1996 Annual Data Report[13], which reported 53.6% males nationwide. Descriptive information was available on 24 of the participants. The mean age of the participants was determined to be 24.12 years with a standard deviation of 5.90 years and a range of 14 to 34 years of age. This age is considerably older than the national mean age of the cystic fibrosis population reported to be 16.0 years. The participants in the study had a mean height of 163.25 cm, a standard deviation of 10.30 cm and a range of 140 to 180 cm. The mean weight of the participants was 51.771 kg with a standard deviation of 10.665 kg and a range of 28.6 to 77.1 kg. See Table 4.6.

Pulmonary function testing data was available on 24 of the participants, and mean values were computed for FEV_1, percent predicted FEV_1, FVC, and percent predicted FVC. The tests were performed within twenty-four hours of admission. The mean FEV_1 was 1.38 liters with a range of 0.56 to 3.01, and the mean percent predicted FEV_1 was 39.08% with a range of 15% to 70%. The Cystic Fibrosis Foundation reports a mean FEV_1 percent predicted of 72.3%. The mean FVC was 2.26 liters, with a range of 0.95 to 3.88. The mean percent predicted FVC was 55.21% with a range of 28% to 85%. The mean percent predicted FVC reported by the Cystic Fibrosis Foundation is 84.5%. See table 4.6.

	Study Participants	National CF Registry
Age (yrs)	24.12 (5.90)	16.0
Height (cm)	163.25 (10.30)	
Weight (kg)	51.77 (10.66)	
FEV_1	1.38 (0.61)	
% pred FEV_1	39.08 (13.98)	72.3
FVC	2.26 (0.80)	
% pred FVC	55.21 (16.21)	84.5

Table 4.6 Demographic Information, reported as mean (SD), comparing study sample and national cystic fibrosis population.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Summary

Cystic Fibrosis is a genetic abnormality of the exocrine glands. One of the significant clinical manifestations of this disease is the abundant and viscous bronchial secretions. These secretions lead to obstruction of the bronchi and predispose the individual to chronic pulmonary infections. As a result, daily care of the cystic fibrosis patient must include bronchopulmonary hygiene to enhance expectoration of secretions and to decrease the frequency of pulmonary complications. Currently, there are several methods of bronchopulmonary hygiene utilized, including Conventional Postural Drainage and Percussion (PD&P), Intrapulmonary Percussive Ventilation (IPV) and High Frequency Chest Wall Compressions (HFCC). The purpose of this study was to directly compare these treatment modalities in hospitalized patients experiencing an acute pulmonary exacerbation of their cystic fibrosis, determining their therapeutic effectiveness and acceptance. This valuable information will allow for improved therapeutic decisions regarding the care of patients with cystic fibrosis in the future.

This inpatient study was designed with a six day protocol in which each patient received two days of each of the three modalities. Each participant was randomly assigned to one of six treatment sequences upon admission into the study. Twenty-seven patients finished the protocol between February 1996 and July 1997. Data were collected regarding the characteristics of the participants, including age, sex, height, weight and pulmonary function values. Wet and dry sputum weights were calculated and statistically tested for differences, and survey information was collected from the participants regarding the convenience, effectiveness and efficacy of each of the modalities in the hospital and for use at home.

Discussion of the results

The discussion of the results will be presented in the order the research questions were asked. The results of the ANOVA with repeated measures produced mixed results. The wet mean sputum weight results approached statistical significance with a $p=0.050$. This may indicate that IPV encourages more expectoration of less viscous sputum than both HFCC and PD&P. The wet sputum weight includes any saliva or other liquid expectorated along with the sputum. The addition of the saliva and other liquids decreases the viscosity of the sputum. However, it can be concluded is there is no evidence of a greater efficacy of one modality compared with another. These results are similar to the results of Arens et al[9], Braggion et al[10] and Kluft et al[11] who each have concluded that HFCC, IPV and/or PD&P all have similar short-term effects on sputum

clearance during active pulmonary exacerbation in hospitalized patients with cystic fibrosis.

The results of the ANOVA for the mean dry sputum weight were not statistically significant with a p=0.140. This indicates that there is no difference in the ability of the three modalities to encourage expectoration of viscous sputum. Each modality appears to be as effective as another. The apparent mixed results between wet and dry weights is similar to the findings of Kluft et al[11] who reported no statistically significant difference in dry weights of nine patients analyzed separately for receiving rhDnase treatments. In this study, there is no evidence of a greater short-term efficacy of one treatment modality as compared to another.

The overall results of the participant questionnaire suggest there is not a consensus regarding the effectiveness, comfort, convenience or ease of use for any of the three modalities utilized in the study. The participants rated the modalities at different levels in all categories. There were a few categories where the participants appeared to be in agreement. For example, only 5% of respondents felt PD&P would be the most convenient modality to use at home while 50% feel IPV is most convenient and 46% feel HFCC is most convenient. This suggests that each individual must decide for him/herself which modality is a balance of comfort, convenience, ease, and efficacy.

The participants' perceptions regarding the efficacy for sputum clearance of each of the modalities was different than the actual amount produced. For both the wet and dry weights, IPV produced the most sputum, with PD&P second and HFCC third. However, the participants felt PD&P produced the most sputum and IPV produced the least. This

inconsistency could be accounted for by considering the other factors that may have clouded the participants perception. One of these factors could be the sequence the participant was placed in. If they had PD&P as their first modality, they may have been more productive on their first two days of admission and would choose PD&P as the most effective modality. However, their sputum production may have had less to do with the modality and more to do with their clinical course.

Another factor affecting the participants' perceptions of the effectiveness of the therapies is their personal preferences. Some participants may have chosen the modality they like to use or they use at home regardless of how much it actually encouraged expectoration for them during the study. Participants may have also answered biased toward what they consider to be the "gold standard" therapy, PD&P, or what they think they should be using. Both of these reasons may account for the differences in the participant's perceptions of effectiveness and the actual amount of sputum produced with each modality.

The last research question asked if the participants were similar demographically to the national data compiled by the Cystic Fibrosis Foundation. The study population was very similar to the national means with regard to the sex of the participants. However, the study population was not as similar to the national means on age and percent predicted FEV_1 and FVC. The difference in the age can be accounted for by considering that the inclusion criteria developed for the study dictated that the participants be over the age of twelve in order to ensure compliance with the protocol. The participant's were all hospitalized during the study, which accounts for the difference in the percent predicted

FEV_1 and FVC values. The national means are not calculated for only hospitalized patients, thus making it difficult to make a comparison regarding the degree of obstruction and impairment. The study population had a greater degree of obstruction than the national means.

Limitations:

There were several limitations to this study. First, the protocol required a minimum length of stay of six days. In these days of cost containment and home IV antibiotic therapy, six days is much longer than the average length of stay. As a result, the number of eligible participants was diminished and skewed toward those with a greater disease severity. In addition, some potential participants declined to participate in the study because they did not want to experience all three modalities. They had had bad experiences in the past with one of the modalities and would not complete the study because it involved all three modalities.

The participants in the study had a greater degree of obstruction than the nationally reported statistics from the Cystic Fibrosis. This could limit the generalizability of the results. The study population was only those patients that were hospitalized for a pulmonary exacerbation of their disease. The results cannot be inferred to other settings, specifically to the home.

Implications:

The results of this study clearly indicate that HFCC and IPV are at least as effective as conventional PD&P for the hospitalized patient with cystic fibrosis. However, a follow-up study with a larger sample size may be necessary to validate these findings.

Some of the results of this study may also warrant another look. For example, it may be beneficial to exclude all participants with "normal" pulmonary function data, specifically those with a percent predicted FEV_1 greater than 80%. These patients do not have a significant degree of obstruction, and may not have a significant response to any method of therapy. In addition, those patients with severe obstruction (a percent predicted FEV_1 less than 50%) should be included in a separate data analysis to determine the benefit of each of the modalities for this population.

A secondary analysis of wet sputum weights needs to be completed for those participants with DNase therapy. DNase is a drug that has a direct effect on the viscosity of sputum. The wet weight of sputum expectorated is related to the viscosity of the sputum. Further analysis of the data may indicate that the combination of DNase and chest physical therapy may encourage the expectoration of the most wet sputum.

The role of HFCC, IPV and PD&P needs to be established for the long-term care of cystic fibrosis patients. Monitoring the number of pulmonary exacerbations and tracking patient compliance with therapy over time would be valuable information leading to better decisions regarding patient care in the future.

Each individual patient must decide which treatment modality is the right balance of comfort, convenience, ease and efficacy for their current situation. Determining

qualitatively which modality is the most effective is important, but patients' willingness to use the therapy must also be considered. The therapy can only be effective if it is actually used.

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APPENDIX A

Helping Hand

Children's Hospital

Ongoing Education and Literature Program

Children's Hospital
Columbus, Ohio 43205-2696

614-461-2000
614-461-2633 (FAX)

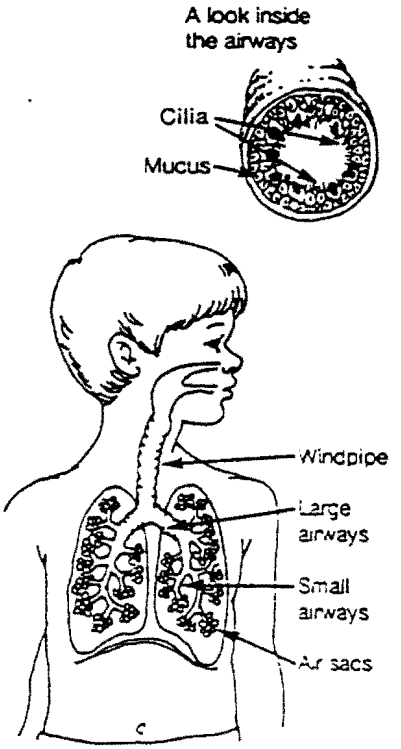
CHEST PHYSICAL THERAPY (CPT): CHILDREN AND ADULTS

Chest Physical Therapy (CPT), also called postural drainage, is a way for you to help your child get rid of extra mucus in his lungs. This is important because too much mucus can block the air passages in the lungs. Giving a CPT treatment to your child at home helps keep extra mucus from building up.

HOW DO THE LUNGS WORK?

We breathe in air (inhale) through the nose and mouth. The air goes through the windpipe into the large airways in the lungs (Picture 1). Then the air goes into the small airways and into the air sacs.

The air sacs in the lungs do important work. The oxygen from the air, which we need to live, goes into the blood through the air sacs. The used oxygen is changed into carbon dioxide in the blood. The carbon dioxide goes from the blood into the air sacs and into the air we breathe out (exhale).



Picture 1 The lungs inside the body.

WHAT IS MUCUS?

All the parts of the lung have a protective mucous lining. The mucus that covers the lining catches tiny pieces of dirt, dust, and other particles in the air we breathe. These particles would irritate the lungs or cause infection if they stayed in the lungs.

HOW DOES THE MUCUS GET OUT OF THE LUNGS?

All the parts of the air passages are lined with tiny hairs called cilia (Picture 1). The cilia act like an escalator and carry the mucus and particles up to the windpipe to be coughed out or swallowed.

WHAT HAPPENS IF THERE IS TOO MUCH MUCUS?

Normally, there is just the right amount of mucus in the lungs. But when the lungs become irritated or infected, a large amount of thick mucus is produced. This happens because the lungs are working extra hard to get rid of the infection or irritation.

Extra mucus can slow down or stop the cilia from working. If the cilia do not work well, we have to help the lungs get the mucus out. This is why CPT is done.

This extra mucus can block the air passages. If air passages are blocked, the air cannot move in and out of the air sacs. Then the child does not get enough oxygen into his blood and does not get enough carbon dioxide out of his blood.

DOCTOR'S ORDER

- The CPT chart on pages 4 and 5 is marked for your child. This chart shows the positions you should use.
- The length of time spent giving CPT is different for each child. The doctor or nurse will tell you how long to spend on each area.
- Give your child CPT at these times: _____.
- Spend _____ minutes on each area.
- Give this treatment before the child eats. (The positioning may cause vomiting or stomach discomfort if there is food in the stomach.)

HOW IS CPT DONE?

CPT helps to move the extra mucus into the windpipe where it can be coughed up more easily. There are 4 steps in CPT: 1. Positioning, 2. Clapping, 3. Vibrating, and 4. Coughing.

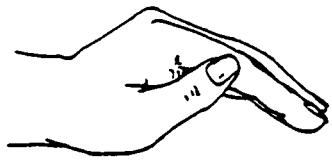
1. Positioning

- The child should be positioned so that the part of the lung to be drained is higher than any other part of the lung.
- It is important for you to be in a comfortable position because this makes the treatment more effective and easier for both you and your child.
- Your child can lie on a padded board. You may use a pillow to make your child more comfortable.
- Always have your child's knees and hips bent to help him relax and to make coughing easier.
- You can get the needed slant for head-down positions by placing one end of a bed or board on blocks. Ask your nurse about other methods used for the head-down positions.

2. Clapping

Before you begin, explain to your child that the clapping will make a noise like a galloping horse or like drums in a parade.

- Place a lightweight towel or blanket over the child's chest or back.
- Cup your hands by bending them at the knuckles. Hold your thumb against your index finger. Keep your fingers together to form a cup (Picture 2).
- Clap your hands, first one and then the other, on the area of the child's chest or back.
- Do the clapping in a regular rhythm.
- Do the clapping fairly fast. The rate of clapping should be comfortable, and not so fast that you get too tired.
- The clapping should be firm so the mucus in the lungs will be moved.
- During the clapping, the child should breathe normally.
- Clapping, when done properly, does not hurt. It is very important that your child does



Picture 2 Hold your hand like this to form a cup for clapping.

Picture 3 Hold your hand like this to vibrate.

HOW IS CPT DONE? (Continued)

3. Vibrating

After the clapping, vibrating is done over the same area of the lung.

- To do the vibrating, hold your hand in the position shown in Picture 3 (page 2). Place your hand flat over the area to be vibrated. Stiffen your shoulder and arm so your whole shoulder, arm, and hand vibrates (like shivering). Make sure not to use just your fingertips.
- The vibration should be done with **gentle**, downward pressure on the area.
- Start each vibration at the outside edge of the chest or back and move slowly towards the center.
- Have your child take a regular breath. Vibrate as the child exhales (breathes out) completely.
- Vibration should be repeated for 5 breaths out.
- If the child can, have him say "SSSS" when he breathes out.

4. Coughing

- After the mucus has been loosened by clapping and vibrating, have the child cough and spit out as much mucus as possible. Have your child start coughing in the position he is in. The child may then sit up if necessary.
- If you see any blood or blood streaks in your child's mucus, tell your nurse or doctor.

PUTTING IT ALL TOGETHER

1. Refer to the pictures on pages 4 and 5.
2. Place the child in the first position.
3. Clap for 1 minute and vibrate 5 breaths out.
4. Then clap for another minute in this same position, vibrate 5 times again.
5. Encourage coughing. (Your child may not be able to cough up something after each position.)
6. Repeat steps 3 through 5 for each position marked.

OTHER INFORMATION

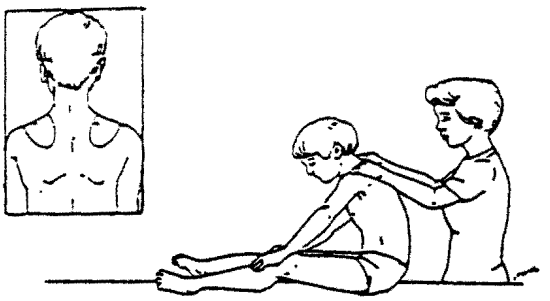
You may want to purchase a percussor for an older child to perform CPT on his own. Several types of percussors are available for home use. Ask your doctor or nurse for information.

If you have any questions, please ask your doctor or nurse.

CHEST PHYSICAL THERAPY (CPT):
CHILDREN AND ADULTS

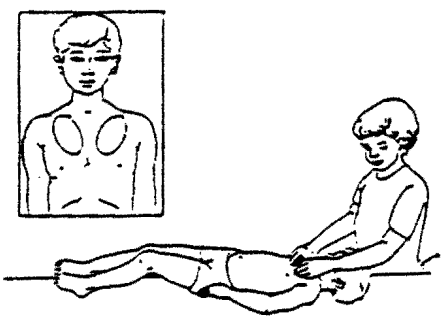
HH-II-20

❑ 1. **Upper lobes - apical posterior segments**



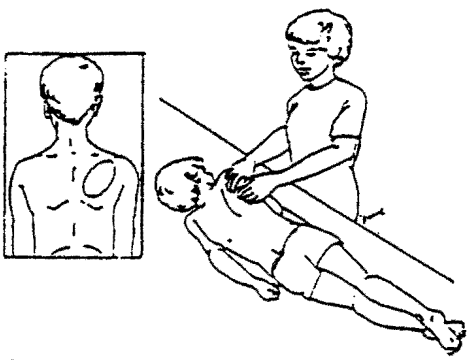
Lean your child forward. Clap on the shoulders on both sides.

❑ 2. **Upper lobes - apical and anterior segments**



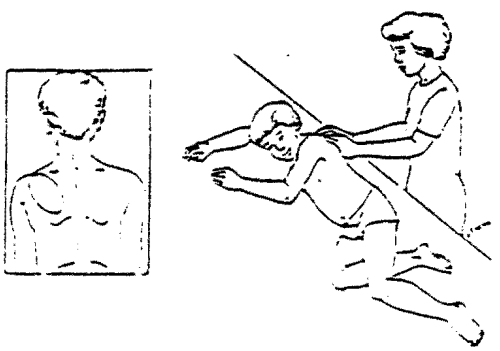
Lay your child flat on his back. Clap just below the collar bone.

❑ 3. **Right upper lobe - posterior segment**



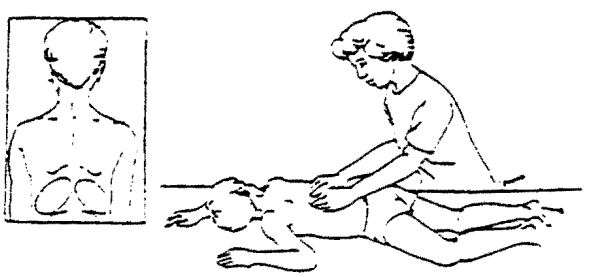
Lay your child on his left side with chest elevated 45°. Roll your child slightly forward. Clap over the right shoulder blade.

❑ 4. **Left upper lobe - posterior segment**



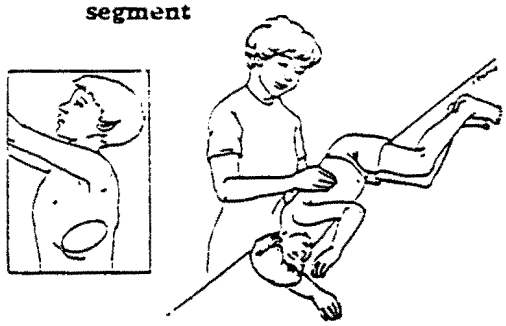
Lay your child on his right side with chest elevated 45°. Roll your child slightly forward. Clap over the left shoulder blade.

❑ 5. **Lower lobes - apical segments**



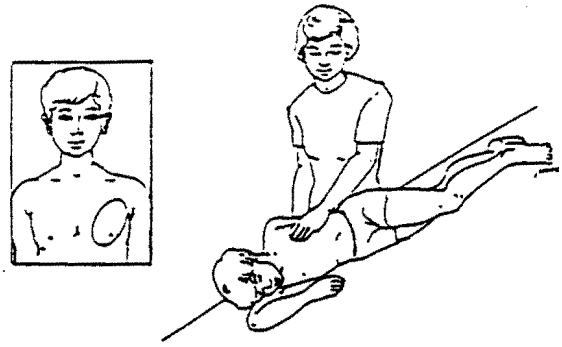
Lay your child flat on his stomach. Clap over the lower ribs.

❑ 6. **Left lower lobe - lateral basal segment**



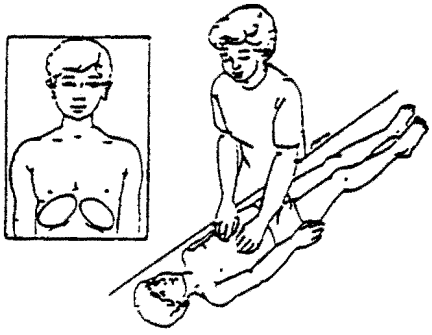
Lay your child on his right side with his head and chest down 45° and knees bent. Clap over the lower ribs.

❑ 7. **Left upper lobe - lingular segment**



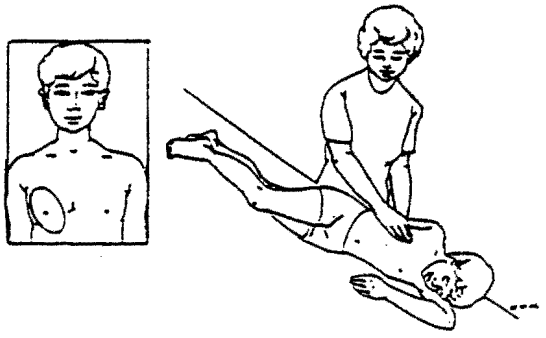
Lay your child on his right side. Clap over the left nipple.

❑ 8. **Lower lobes - anterior basal segments**



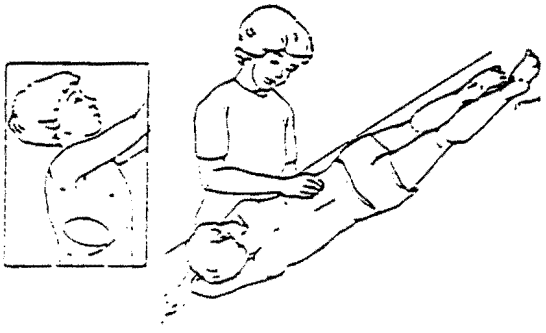
Lay your child on his back with head and chest down 45°. Clap over the lower ribs.

❑ 9. **Right middle lobe**



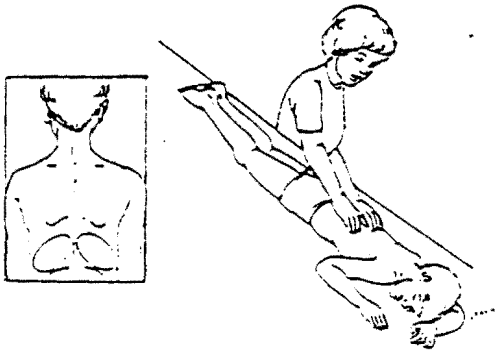
Lay your child on his left side with head and chest down 45°. Roll your child slightly backward. Clap over the right nipple.

❑ 10. **Right lower lobe - lateral basal segments**



Lay your child on his left side with head and chest down 45° and knees bent. Clap over the lower ribs.

❑ 11. **Lower lobes - posterior basal segments**



Lay your child on his stomach with head and chest down 45°. Clap over the lower ribs.

APPENDIX B

COLUMBUS CHILDREN'S HOSPITAL 2301-2
RESPIRATORY CARE
POLICY AND PROCEDURE

PROCEDURE: Intrapulmonary Percussive Ventilation

WRITTEN BY: Lisa Smith, Kevin Peters, and John Servick

DATE APPROVED: April 12, 1993
REVIEW DATE: 6-16-95

APPROVED:
John Servick
Director of Respiratory Care

APPROVED:
Karen McCoy, M.D.
Medical Director, Respiratory Care

****
****

I. Purpose

To provide patients diagnosed with Cystic Fibrosis or other selected conditions with impaired clearance of secretions Intrapulmonary Percussive Ventilation(IPV). IPV combines standard aerosol therapy and postural drainage into one treatment.

II. Procedure

A. Check physician order which should include IPV therapy, treatment frequency and medication.

B. Identify patient.

C. Plug machine into wall outlet. Set the driving pressure at 25 PSI initially; however, the patient may require an increase in the PSI to assure adequate chest excursion.

1. The driving pressure is adjusted by the knob inside of the IPV cabinet.
2. The red locking ring must be pulled out to adjust the driving pressure.
3. After an adjustment is made the remote button must be depressed once. This will allow the pressure gauge to read the new pressure.
4. Disconnect from the wall outlet before adding the medication.

D. Assemble circuit. (See diagram)

E. Place the ordered drug and diluent in the nebulizer cup.

F. Instruct the patient using method 1 or method 2. Start by using method 1 on all new starts. Once the patient becomes comfortable with method 1 and you want to get more percussion to the patient, switch over to method 2.

NOTE: Any patient using method 2 consistently, should have previously been instructed on method 1.

Method 1:

* Place the mouthpiece into mouth behind their teeth.
* Seal their mouth firmly around the mouthpiece and keep facial muscles taunt.
* At the beginning of inhalation depress the silver remote button and slowly inhale (3-5 seconds).
* Near the end of the breath the patient should release the button and exhale through the circuit.

Method 2:

* Place the mouthpiece into mouth behind their teeth.
* Seal their mouth firmly around the mouthpiece and keep facial muscles taunt.
* Have the patient hold down the silver remote button as they inhale and exhale through the circuit.
* If the patient requires a rest period, have them release the remote button as they continue to breath through the circuit.

G. Set the frequency/impact knob fully clockwise initially; however, the patient may wish to increase the impact by turning the knob counter clockwise.

H. Assess the patient's breath sounds, heart rate, respiratory rate, and signs of noted distress.

I. Plug the IPV into the wall gas source.

J. Treatment

1. Coach and monitor the patient in proper technique. Adjust the PSI and impact knob as needed.

2. Monitor the patient for any adverse reactions. Encourage the patient to take breaks and cough during the treatment.

3. Continue the treatment for duration of medication unless any adverse reactions were noted. Treatments should last approximately 20 minutes.

4. Assess the patient's breath sounds, heart rate, respiratory rate, patient tolerance, adverse

reaction, cough, and sputum (amount, color and consistency).

5. Remove the patient circuit from the IPV machine, and place the circuit in the patient set-up bag.

6. Wipe all external surfaces and hoses with Wexcide or an equivalent disinfectant between treatments.

7. Document the date/time, PSIG, medication, diluent, Pretreatment assessment (#9), and the post treatment assessment on a Respiratory progress notes RC-6.

III. Equipment

A. IPV Machine.

1. The IPV machine will be kept in the Respiratory Care Department.

B. IPV circuit.

1. Circuits will be changed Q 3 days on evenings.

2. The circuit bag will have the patients name and date the circuit was changed.

3. Extra circuits will be kept in the Respiratory department.

4. Mouth pieces with adapters will not be attached or packaged with the circuit. Make sure you select the appropriate mouthpiece and 2 links of corrugated tubing.

C. Medication

1. The 1/2 normal saline will be sent up from pharmacy for each patient.

IV. IPV For Homecare

A. Patient Setup

Plug machine into electrical outlet. Set the driving pressure at 25 PSI initially; however, the patient may require an increase in the PSI to assure adequate chest excursion.

1. The driving pressure is adjusted by the knob next to the pressure gauge.

2. The locking ring must be pulled out to adjust the driving pressure.

3. After an adjustment is made the remote button must be depressed once. This will allow the pressure gauge to read the new pressure.

B. Assemble circuit. (See diagram)

C. Place the ordered drug and diluent in the nebulizer cup.

D. Instruct the patient using method 1 or method 2. Start by using method 1 on all new starts. Once the patient becomes comfortable with method 1 and you want to get more percussion to the patient, switch over to method 2.

NOTE: Any patient using method 2 consistently, should have previously been instructed on method 1.

Method 1:

* **Place the mouthpiece into mouth behind their teeth.**
* **Seal their mouth firmly around the mouthpiece and keep facial muscles taunt.**
* **At the beginning of inhalation depress the silver remote button and slowly inhale (3-5 seconds).**
* **Near the end of the breath the patient should release the button and exhale through the circuit.**

Method 2:

* **Place the mouthpiece into mouth behind their teeth.**
* **Seal their mouth firmly around the mouthpiece and keep facial muscles taunt.**
* **Have the patient hold down the silver remote button as they inhale and exhale through the circuit.**
* **If the patient requires a rest period, have them release the remote button as they continue to breath through the circuit.**

E. **Set the frequency/impact knob fully clockwise initially; however, the patient may wish to increase the impact by turning the knob counter clockwise.**

F. Assess the patient's breath sounds, heart rate, respiratory rate, and signs of noted distress.

V. Treatment

A. Coach and monitor the patient in proper technique. Adjust the PSI and impact knob as needed.

B. Monitor the patient for any adverse reactions.

C. Continue the treatment for duration of medication unless any adverse reactions were noted. Treatments

should last approximately 20 minutes.

D. Assess the patient's breath sounds, heart rate, respiratory rate, patient tolerance, adverse reaction, cough, and sputum (amount, color and consistency).

VI. Cleaning

A. Remove the patient circuit from the IPV machine; rinse the nebulizer cup with tap water after each treatment and let air dry.

B. Wipe all external surfaces and hoses with windex or an equivalent disinfectant between treatments.

NOTE: The hoses are not to be immersed in water and should be left attached to the machine.

C. After the last treatment for the day, clean the phasitron and nebulizer cup using the following method:

1. Disassemble the phasitron and nebulizer cup and wash in dishwashing liquid.

2. Rinse thoroughly with tepid tap water.

3. Place in container of Control 3 and leave in this solution for 20 minutes.

4. Rinse thoroughly and let air dry.

NOTE: Mix the Control 3 according to the package insert. Change solution every two weeks.

VII. Machine Maintenance

A. Lube the following at least twice a week.

1. O-rings on the hoses
2. yellow rubber ring on the nebulizer cup
3. diaphragm on venturi
4. O-ring on venturi

APPENDIX C

COLUMBUS CHILDREN'S HOSPITAL
RESPIRATORY CARE
POLICY AND PROCEDURE

2305-1

PROCEDURE: Use of the High Frequency Chest Wall Oscillator (HFCWO)

WRITTEN BY: Terri Robison RRT

DATE APPROVED: 2-22-95

REVIEW DATE:

APPROVED:
John Servick
Director of Respiratory Care

APPROVED:
Karen McCoy, M.D.
Medical Director, Respiratory Care

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I. Purpose
To provide airway clearance therapy utilizing high frequency chest wall oscillation (HFCWO). The HFCWO produces transient increases in airflow, cough-like forces, alterations in the physical properties of mucus, and increases in mucus mobilization.

II. Equipment
A. Air pulse generator
B. Vest
1. Sizes range from medium child to medium adult.
2. Vests are located in the Respiratory Care equipment room.

III. Procedure
A. Check and sign off the physician's order. Introduce yourself and identify the patient. Wash your hands.
B. Have the patient sit upright or in the semi-Fowler position.
C. Adjust the vest. The vest should fit comfortably when it is deflated. Breathing should not be restricted when it is deflated.
1. On seated patients, the vest should be no longer than the top of the thigh or no shorter than the waist.
2. On patients lying down, the vest needs to be no shorter than the waist.
D. Connect one hose to each of the connector ports on the vest. Either hose can be used on the connector ports, there is no right/left hose.

E. Turn on the main power switch.
F. Adjust the pressure control according to patient comfort.
G. Start the patient's aerosol treatment (albuterol and normal saline or just plain normal saline). It is suggested that the HFCWO be used in conjunction with supplemental humidification/aerosolization to ensure hydration of secretions.
H. Adjust the frequency control to the desired frequency for 5 minutes.
I. Have the patient use the vest intermittently (only on exhalation) or continuously (during both inspiration and expiration) by depressing the hand/foot control.
J. After the 5 minutes have passed, make sure the patient releases the hand/foot control and set the machine to 25 hertz.
K. Instruct the patient to perform a FVC maneuver and depress the hand/foot control during exhalation. Have the patient perform this twice, and after each maneuver encourage the patient to cough to help clear loosened secretions.
L. Repeat steps G-J for the following frequencies
    1. 5 hertz
    2. 10 hertz
    3. 15 hertz
    4. 20 hertz
M. The frequencies may need to be modified for some patients.

V. Maintenance
A. Wipe the hand/foot control off with 70% alcohol or Wexcide after each use. The air pulse generator also needs to be wiped off between patients.
B. If the vest is a non-disposable one make sure it also gets wiped down after patient use with Wexcide. If the vest is a disposable one, make sure the vest is labeled with the patient's name and stored in the patient's room.

VI. Indications
A. Evidence or suggestion of difficulty with secretion clearance.
B. Presence of atelectasis caused by or suspected of being caused by mucus plugging.
C. Diagnosis of diseases such as cystic fibrosis, bronchiectasis, or cavitating lung disease.

V. Contraindications
A. Absolute
    1. Head and/or neck injury which hasn't been stabilized.
    2. Active hemorrhage with hemodynamic instability.

B. Relative
   1. Subcutaneous emphysema
   2. Recent epidural spinal infusion or spinal anesthesia
   3. Recent skin grafts or flaps on the thorax
   4. Burns, open wounds, and skin infections of the thorax
   5. Suspected pulmonary tuberculosis
   6. Lung contusion
   7. Bronchospasm
   8. Complaint of chest wall pain

VII. Charting
   A. Charting will be done on the Respiratory Care progress note.
   B. Charting will include:
      1. Treatment done, patient's heart rate and respiratory rate pre and post treatment, patient's breath sounds pre and post treatment, patient's cough and sputum production, and how well the patient tolerated the treatment.
      2. The frequencies done during the treatment. If the treatment was stopped early, why it was stopped.

APPENDIX D

BRONCHOPULMONARY HYGIENE COMPARISON STUDY
FOR HOSPITALIZED CYSTIC FIBROSIS PATIENTS

PATIENT QUESTIONNAIRE

	Extremely	Very	Somewhat	Not Very	Not at all
How COMFORTABLE was each treatment?					
PD&P	1	2	3	4	5
IPV	1	2	3	4	5
HFCC	1	2	3	4	5
How CONVENIENT was each treatment?					
PD&P	1	2	3	4	5
IPV	1	2	3	4	5
HFCC	1	2	3	4	5
How EFFECTIVE was each treatment?					
PD&P	1	2	3	4	5
IPV	1	2	3	4	5
HFCC	1	2	3	4	5
How EASY was each treatment to use?					
PD&P	1	2	3	4	5
IPV	1	2	3	4	5
HFCC	1	2	3	4	5

With which treatment do you feel you cleared more sputum?

PD&P IPV HFCC

With which treatment do you feel you cleared the least sputum?

PD&P IPV HFCC

Which treatment do you feel is most comfortable to use?

PD&P IPV HFCC

Which treatment do you feel is least comfortable to use?

PD&P IPV HFCC

Which treatment do you think would be most convenient to use at home?

PD&P IPV HFCC

Which treatment do you think would be least convenient to use at home?

PD&P IPV HFCC

Which treatment would you most prefer to use at home?

PD&P IPV HFCC

Which treatment would you least prefer to use at home?

PD&P IPV HFCC