THE EFFECT OF POSTURAL DRAINAGE AND DEEP BREATHING WITH COUGHING UPON MAXIMAL EXPIRATORY FLOW IN PATIENTS WITH CHRONIC BRONCHITIS

by

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ABSTRACT

The purpose of this study was to determine if deep breathing with coughing is as effective as postural drainage in improving maximal expiratory flow (Vmax) at low lung volumes. Changes in Vmax were measured on maximal expiratory flow volume (MEFV) curves. Eleven subjects with a diagnosis of chronic bronchitis participated; five had on previous pulmonary function tests demonstrated minimal responses to bronchodilator inhalation; four demonstrated marked responses; and two had never undergone pulmonary function testing. Each subject participated in two randomly assigned treatment sessions. Composite MEFV curves were obtained prior to starting treatment, 5 minutes after two inhalations of metaproterenol, and 20, 40, and 60 minutes following treatments. No statistically significant changes in Vmax were demonstrated at volumes corresponding to 50 percent and 75 percent baseline FVC, 60 minutes after either form of treatment. A significant difference was found between the responses of subjects with previously demonstrated minimal reversibility of airways obstruction and subjects with marked reversibility. Administration of anticholinergic, rather than beta-2 adrenergic, bronchodilator medication may have antagonized reflex bronchoconstriction. There was no correlation between sputum volume and improvement in lung function. Personal attention from the investigator may have induced subjects' positive subjective perceptions of airways functioning.
CHAPTER 1

INTRODUCTION

Chronic bronchitis is defined epidemiologically as a condition in which there is a persistent productive cough not attributable to any specific cause (Burrows, Knudson, and Kettel, 1975, p. 139). The primary change that occurs is hypertrophy of the bronchial mucus glands. Excessive production of viscid mucus overburdens the mucociliary escalator and cough reflex which are the normal mechanisms maintaining the balance between secretion production and removal. Inflammatory responses, the result of repeated pulmonary infection, lead eventually to scarring of lung tissue. The effectiveness of the cough mechanism is probably reduced in patients with chronic bronchitis not only because of increased mucus secretion but also because of possible changes in airway compliance. Any reduction in the ability to raise secretions leaves the individual susceptible to recurrent infection and ventilatory failure (Loudon and Shaw, 1967, p. 676). Chronic bronchitis is frequently associated with chronic asthma. As the symptoms of each progress over time the association of the two diseases becomes a distinct entity often referred to as asthmatic bronchitis (Kazemi, 1976, p. 110).

Postural drainage with percussion and vibration and deep breathing with coughing are two modes of treatment utilized extensively as adjuncts to the therapy of patients with chronic bronchitis. The
assumption is that airway clearance is facilitated. Few studies have been completed to assess the effectiveness of either treatment. Yet this information would be applicable to nursing care of patients with chronic bronchitis both in hospital and in their homes. These patients require that constant attention be paid to their airway status during both acute and chronic phases of their disease. Whether patients are receiving these treatments from others or treating themselves, it is desirable that they be given the most efficient and effective mode of therapy.

The two forms of treatment, postural drainage with percussion and vibration and deep breathing with coughing, were evaluated empirically and their effects compared in order to establish whether or not the end results of the two treatments were equally satisfactory in decreasing airway destruction. Maximum expiratory flows (Vmax) were measured to obtain objective data by which to determine the changes in airway mechanics following each treatment.

Statement of the Problem

Educating patients with chronic bronchitis regarding the self-care they should be performing is primarily a nursing role in many settings, as is the responsibility of follow-up care. Nurses have a professional obligation to provide instruction based on factual information, not upon assumptions. Clinical assumptions need empirical support. Therefore data substantiating the effects of treatments must be gathered and methods by which to measure treatment effectiveness need to be evaluated.
The excessive secretion production in patients with chronic Bronchitis causes obstruction to airflow and, consequently, a reduction in expiratory flow rates. The end result of both postural drainage treatments with percussion and vibration and deep breathing with coughing treatments is assumed to be a reduction in airway obstruction due to removal of secretions. Neither treatment has been assessed satisfactorily in terms of its effectiveness in facilitating airway clearance. Postural drainage with percussion and vibration is assumed to move secretions by gravity from smaller to larger airways. In the large airways, the cough mechanism is known to effect secretion removal. Deep breathing with coughing requires that the patient perform vital capacity (VC) maneuvers which are known to force air beyond secretions on inspiration, when airways dilate. It is presumed that, as air is expired, secretions are moved mouthwards. Once secretions reach larger airways they can be removed by coughing.

If the deep breathing with coughing treatment is as effective as postural drainage with percussion and vibration in improving airway clearance as demonstrated by improved maximum expiratory flows, it would appear to be a more convenient treatment. It should be relatively easy to educate patients in the proper technique and, furthermore, carrying out the treatment should not be unduly disruptive of patients' lifestyles.

**Purpose of the Study**

The purpose of the study was to determine if deep breathing with coughing was as effective as postural drainage with percussion
and vibration in improving maximum expiratory flows at low lung volumes in patients with chronic bronchitis.

The data substantiating the effectiveness of each mode of therapy are for use by nurses and physicians when prescribing treatment regimes. The maximum expiratory flow volume (MEFV) curve was used to evaluate the degree of airway clearance achieved in patients with chronic bronchitis following both types of therapy.

Hypotheses

1. In subjects with chronic bronchitis, following postural drainage there will be a statistically significant increase, at the 0.05 level, in $V_{\text{max}}$ at volumes corresponding to 50 percent and 75 percent of the largest pre-treatment vital capacity.

2. In subjects with chronic bronchitis, following deep breathing with coughing there will be a statistically significant increase, at the 0.05 level, in $V_{\text{max}}$ at volumes corresponding to 50 percent and 75 percent of the largest pre-treatment vital capacity.

3. There will be no statistically significant difference, at the 0.05 level, in $V_{\text{max}}$ at volumes corresponding to 50 percent and 75 percent of the largest pre-treatment vital capacities between the two forms of treatment.

4. Those subjects who previously demonstrated a marked improvement in forced vital capacity (FVC) following bronchodilator inhalation will have changes in $V_{\text{max}}$ after each treatment.
significantly different at the 0.05 level, from the post-treatment changes in $V_{\text{max}}$ of subjects who did not previously demonstrate improvement following bronchodilator inhalation.

**Definition of Terms**

1. **Postural drainage**: In the present study postural drainage includes postural drainage, percussion, and vibration. Gravitational drainage of basal segments of the right and left lower lobes was accomplished by the subjects assuming four different postures, each corresponding to specific segments of the lung, for a total of five minutes each (see Figure 1). The treatment session included percussion followed by vibration of the lung segments. Percussion was effected by holding the hands slightly cupped with fingers and thumbs together allowing a cushion of air to be trapped between the hand and the chest wall. The area over the lung segment being drained was clapped with the cupped hand. Vibration was effected by initiating a fine tremor at the shoulders which was transferred to the chest by firm downward pressure of the flats of the hands placed over the lung segment being drained. The wrists are held in rigid flexion and the elbows are stiff with arms slightly abducted. The area over the lung segment being drained was first percussed for one minute. Vibration was then carried out during three prolonged exhalations from total lung capacity (TLC) to residual volume (RV).
A. Left and Right Anterior Basal Segments

B. Left and Right Posterior Basal Segments

C. Left Lateral Basal Segment

D. Right Lateral Basal Segment

Figure 1. Postural Drainage Positions — Adapted from Feldman (1976, p. 7), with written permission from the author.
2. **Deep breathing with coughing:** Subjects performed slow inhalations to TLC followed by slow exhalations, through pursed lips, to RV three times in succession. On the third VC maneuver, subjects were required to cough near RV. The succeeding breath was a deep inspiration to TLC followed by a series of coughs down to near RV.

3. **V_{max} 50 percent:** Maximum expiratory flow achieved after exhaling 50 percent of the total forced vital capacity.

4. **V_{max} 75 percent:** Maximum expiratory flow achieved after exhaling 75 percent of the total forced vital capacity.

**Theoretical Framework**

The pathology of chronic bronchitis involves mucus gland hypertrophy, increased numbers of goblet cells and accompanying reduction in numbers of ciliated epithelial cells. Excessive mucus production and impaired ciliary transport necessitate that patients with chronic bronchitis rely heavily on the cough mechanism to keep their airways free of secretions (Loudon and Shaw, 1967, p. 666). Because of the relationship between chronic bronchitis and chronic asthma (Kazemi, 1976), a group of patients exists whose primary diagnosis is chronic bronchitis but in whom a considerable degree of bronchospasm can be demonstrated by pulmonary function studies carried out before and after administration of inhaled bronchodilator medication.

Bronchospasm refers to any type of reversible airways obstruction whether due to bronchial mucosal oedema or congestion or smooth muscle contraction (Burrows et al., 1975, p. 134). It is
pathognomonic of both chronic bronchitis and asthma. The relative prevalence of each of these factors varies from patient to patient and from time to time in the same patient (Snider, 1976, p. 33). Bronchospasm and concomitant wheezing can be induced in persons with reactive airways by coughing, exposure to irritants such as smoke, fog or cold air, or during acute exacerbations of disease (Kazami, 1976, p. 105).

More than one theory exists regarding the role of the autonomic nervous system in the pathogenesis of bronchospasm. Sympathetic regulation of the lungs is apparently achieved via circulating catecholamines rather than by direct innervation (Brocklehurst, 1976, p. 118). A balance between alpha and beta adrenergic receptor systems mediates bronchomotor tone. The normal balance favors a beta effect, that is, relaxation of bronchial smooth muscle (Szentivanyi, 1976, p. 140). Szentivanyi (1968) postulated the beta-adrenergic theory of asthma which states that an absolute or relative deficiency of beta-adrenergic receptors exists. The relative unavailability of a beta effector system permits an increase in bronchial smooth muscle tone.

The parasympathetic nervous system, via the vagus nerve, has the predominant influence over bronchomotor tone (Brocklehurst, 1976, p. 117). The vagus nerve has been shown, in dogs, to play a role in bronchospasm. Rises in airways resistance evoked in sensitized dogs challenged with allergen were prevented by blockade of either efferent or afferent nerves of the vagus (Brocklehurst, 1976). Gold, Kessler, and Yu (1972) demonstrated the reflex nature of
vagally mediated bronchospasm in dogs by antigen challenge of one lung which resulted in bronchoconstriction of both lungs. This bilateral bronchoconstriction could be inhibited by cooling the vagus nerve innervating the challenged lung.

For patients with chronic bronchitis teaching proper cough techniques is an important part of treatment. The sequence of events which produces cough is well known. Quick, deep inspiration is followed by forced expiratory effort against a closed glottis. At the height of this effort the glottis opens resulting in rapid, forceful expiration. The deep inspiration causes transient airway dilation which allows air to pass beyond secretions. Forced expiratory effort against the closed glottis causes a high intrathoracic pressure to develop. The rapid expulsion of air when the glottis opens shears excess secretions from the sides of airways and forces them toward the mouth. Vital capacity maneuvers performed prior to coughing result in rhythmic expansion and contraction of peripheral airways which is thought to milk secretions downstream, that is, mouthward, into airways where the cough mechanism can effect their removal (Traver, 1977, p. 3).

Both postural drainage and deep breathing maneuvers are assumed to move secretions from peripheral airways to proximal airways where they are subsequently expelled by cough. If the assumption is true the effect of secretion removal should be demonstrable on flow volume curves with an improvement being seen in Vmax following treatments. Expiratory flows at low lung volumes can be evaluated by recording Vmax 50 percent and Vmax 75 percent. These flows are a
reflection of the small airway mechanics which will be reviewed in this chapter, together with the airway mechanics associated with effective coughing at both high and low lung volumes.

Cough

The cough reflex only occurs in normal individuals when mucociliary transport is ineffective or overwhelmed (Macklem, 1974, p. 761). The reflex is stimulated via receptors in the trachea, bronchi and bronchioles which respond to chemical and mechanical stimulation. These receptors are stimulated by inert particles, probing with a catheter, histamine and certain gases. Constant chemical stimulation leads to adaptation, and subsequent depression, of the reflex (Burrows et al., 1975, p. 100). Unusually large inflations or deflations of the lungs may also stimulate cough (Comroe, 1974, p. 79).

An effective cough is one that adequately removes irritant gases, particles, excess mucus, cellular debris or pus from the airway. Two factors are necessary: (1) the high velocity of gas and (2) a reduction in airway cross-sectional area which occurs at any given lung volume as a result of dynamic compression of airways (Macklem, 1974, p. 761).

The linear velocity of gas for a given flow is related to the cross-sectional area of various generations of airways. With successive branching of the airways from trachea to alveolar ducts, the total cross-sectional area increases (see Figure 2). The total air flow is disseminated throughout an ever increasing area so that
Figure 2. Increases in Total Airway Cross-Sectional Area from Trachea to Alveoli -- From Burrows and Hasan (1977, p. 9), reproduced with permission.
velocity diminishes in those airways less than 2 mm in diameter (Burrows and Hasan, 1977, p. 9).

Linear velocity of mucus is related to its viscosity. Since both liquid and gas are moved in the airways, the viscosity of the sputum will effect the air velocities required to mobilize it. The mist spray which is observable during cough is evidence that velocities high enough to shear droplets of liquid from the sides of the airways and to carry them as mist are achieved. Lower velocities permit movement of mucus plugs as gas rises through the liquid at less speed (Leith, 1968, p. 442).

Dynamic compression of airways occurs as a result of the diminishing pressure gradient which exists from alveoli to mouth at any given lung volume. The pressure at the alveoli (Palv) is the sum of lung static elastic recoil pressure (Pst(1)) and pleural pressure (Ppl). The static recoil pressure is a function of volume whereas Ppl is effort dependent. Figure 3 illustrates the fact that, because airway pressure decreases toward the mouth, at some point lateral pressure within the airways will equal Ppl. These equal pressure points (EPP) are not fixed but are determined by lung volume and Pst(1). At high lung volumes EPP are in lobar or segmental bronchi. At low lung volumes they move peripherally toward the alveoli. Downstream, mouthward, of the EPP flow is limited by dynamic compression of the airways while, at the same time, reduction in airway cross-sectional area brought about by the compression increases linear velocity. The amount of dynamic compression is related to Ppl while the length of compressed airway is dependent upon Pst(1). The degree
$Pst(l) = $ elastic recoil pressure
$Palv = $ alveolar pressure
$Ppl = $ pleural pressure
$EPP = $ equal pressure point
$V_{max} = $ maximum expiratory flow

Figure 3. Schematic Model of the Respiratory System During Maximum Expiratory Flow -- From Burrows et al. (1975), reproduced with permission.
to which airways resist compression is dependent upon factors intrinsic to the airways themselves (Burrows et al., 1975, pp. 33-36). Some patients with chronic bronchitis have greater than normal airway compliance permitting excessive compression and further limitation of expiratory flow (Wright, 1960; Leith, 1968).

The linear velocity of a given volume flow depends upon reduction in airway cross-sectional area. Normally, during cough the high intrathoracic pressure achieved during the forced expiratory effort causes the trachea and mainstem bronchi to be compressed to one-quarter to one-sixth of their relaxed lumen size (Burrows et al., 1975, p. 101) which further enhances the increased linear velocity of air and liquid in the central airways.

Successive coughing at progressively decreasing lung volumes results in displacement of the EPP to more peripheral airways. Thus, the cross-sectional area of airways is sequentially reduced over a larger and larger proportion of the tracheobronchial tree, theoretically increasing linear velocity in those airways which are dynamically compressed. However, at low lung volumes Pst(l) is diminished so that flow, and therefore linear velocity, decrease accordingly even though cross-sectional area is reduced.

Nonetheless, coughing at low lung volumes is instrumental in moving secretions by plug flow from peripheral to central airways from which secretions can be expelled by the extremely high linear velocities generated there (Burrows et al., 1975, p. 101). Cascading cough following a single inspiration may, because of alternating compression and expansion of airways, loosen tenacious secretions allowing them to
be moved downstream to central airways from which they can be removed by subsequent coughing (Burrows et al., 1975, p. 102).

Maximum Expiratory Flow Volume Curve

Maximum expiratory flow volume curves plot $V_{\text{max}}$ against lung volume during a forced expiration beginning at TLC (see Figure 4). Air flow rises abruptly to peak expiratory flow then drops as lung volume approaches RV. At large lung volumes flow rates are high because airway resistance decreases as lung volume and, therefore, airway caliber increase. The flow rate of the first 20 percent of the total expired volume to be exhaled is dependent upon the effort generated by the subject. The flow for the remaining portion is independent of effort to the degree that no higher flows can be achieved by increasing muscular effort during expiration. Flow in that portion of the curve is dependent upon $P_{\text{st}(1)}$ and airway dimensions (Comroe, 1974; Motoyama, 1973).

The resistance to flow in the airways upstream, alveolarward, from the EPP ($R_{\text{us}}$) and $P_{\text{st}(1)}$ determine $V_{\text{max}}$ (Mead et al., 1967, p. 95). Reduced $P_{\text{st}(1)}$ and narrowed airways both result in lower $V_{\text{max}}$ values (Comroe, 1974, pp. 134-135). Bronchial smooth muscle tone, mucosal thickness and the presence of secretions all modify airway caliber (Burrows et al., 1975). Therefore, if airway caliber is reduced due to the presence of secretions the resistance in that airway will increase resulting in a reduction in $V_{\text{max}}$.

Even though subjects with chronic bronchitis may have abnormal lung recoils this characteristic is unlikely to change during the time
TLC = total lung capacity
RV = residual volume

Figure 4. Maximal Expiratory Flow Volume (MEFV) Curve
of their participation in this study. Therefore, any change in \( \dot{V}_{\text{max}} \) at low lung volumes demonstrated on MEFV curves was interpreted as reflecting a change in \( \text{Rus} \) and assumed to be due to mobilization of secretions from peripheral airways.

**Assumptions**

1. The presence of sputum in the airways increases resistance to air flow.

2. Changes in maximum expiratory flow at 50 percent and 75 percent of the expired vital capacity reflect changes in airway resistance upstream from EPP.

3. There was no change in subjects' total lung capacities during their participation in the study.

**Limitations**

1. Generalizations from the study cannot be extended to a population other than the sample studied.

2. Maximum expiratory flow volume curves measure the degree of airway resistance indirectly and are also affected by lung elastic recoil.
CHAPTER 2

REVIEW OF THE LITERATURE

Literature pertaining to airway clearance and airway obstructive
disease was reviewed. Relatively few controlled studies validating
or disproving the clinical assumptions regarding the effectiveness of
either postural drainage or deep breathing with coughing in facilitating
airway clearance were available. Studies of airway clearance
mechanisms in subjects with chronic lung disease were not conclusive.
Recent literature on the treatment of bronchospasm is providing new
information on the usefulness of anticholinergic drugs as broncho-
dilators. Literature pertaining to the use of MEFV curves reveals
that they are a sensitive measure of degree of airway obstruction.

Airway Clearance

In normal adults the estimate of daily mucus production ranges
from 10-100 ml (Burrows et al., 1975, p. 100). It forms a sheet
equally covering the epithelium. The sheet has two distinct layers,
a lower serous watery layer and an upper more viscous layer containing
glycoprotein (Blake, 1975). Its purpose is twofold, firstly it pro-
tects the airways from injury or drying. Drying is thought to cause
irreversible damage to cilia (Comroe, 1974, p. 223). Secondly, it
provides a cleansing medium. Particles are deposited on the mucus
sheet as they are drawn into the airways with inspired air. Hypertrophy
of gland cells and an increased number of goblet cells occur in
response to chronic irritation (Comroe, 1974, p. 224). Both are present in chronic bronchitis which accounts for the excessive amount of secretions continually present.

Sanchis et al. (1973) found that, in a group of 19 patients with chronic bronchitis or emphysema, clearance of an inhaled radioactive aerosol was as fast or faster than clearance from a group of nine non-smokers' lungs. In the normal subjects deposition of aerosol particles was preferentially peripheral whereas in subjects with airway obstruction the aerosol was deposited on more proximal airways. Since most of these particles were removed by mucociliary escalator in the large airways total lung clearance was faster than, or equal to, clearance in normal lungs. In this study gross differences in amount of secretion seemed to have little influence on clearance rates. Sanchis et al.'s group did not assess the cough mechanism.

Newhouse et al. (1973) measured removal of inhaled radioactive aerosol from the lungs of 13 children with cystic fibrosis and nine normal adults. A greater variance in clearance was found among the cystic fibrosis group than among the normal group. In the normal group most of the aerosol was deposited beyond the terminal Bronchioles. In the cystic fibrosis group there was more proximal deposition of aerosol so that airway clearance was dependent upon the efficiency of mucociliary function. Central airway clearance was almost identical in both groups, but in the children alveolar clearance was slow. In those children with decreased mucociliary function cough was an important ancillary mechanism for removal of secretions.
Treatment of Bronchospasm

During the 1960's the specificity of beta adrenergic receptors was discovered. Treatment of bronchospasm is currently directed toward finding agents which stimulate beta-2 adrenergic receptors. These receptors function to effect relaxation of bronchial smooth muscle (Leifer and Wittig, 1975). Adrenergic therapy of bronchospasm requires drugs which either stimulate beta receptors or overcome high threshold levels at receptor sites. One of these drugs is isoproterenol, which is administered by inhalation and stimulates both beta-1 and beta-2 adrenergic receptors (Leifer and Wittig, 1975). Metaproterenol, an analogue of isoproterenol has selective activity on the beta-2 adrenergic receptors in bronchial smooth muscle (Lyons, 1976). Metaproterenol has a rapid onset of action (Miller, 1967), the duration of which, after a single dose, is from one to four hours (Leifer and Wittig, 1975).

Cavanaugh and Cooper (1976) compared the effects of anticholinergic and adrenergic compounds in the treatment of bronchospasm in 20 asthmatic children. Atropine was demonstrated to be as effective as isoproterenol 30 minutes after inhalation and significantly more effective from one to five hours after inhalation as measured by improvements in V̇max 50 percent and V̇max 75 percent.

Poppius and Salorinne (1973) compared the effects of the anticholinergic drug Sch 1000 to those of the beta adrenergic drug Salbutamol in 20 patients with chronic bronchitis and moderate to severe airways obstruction. Only one subject had a personal history of atopy. Sch 1000 produced a larger increase in specific airway
conductance than did Salbutamol up to 2 hours after inhalation. The bronchodilator effect of Sch 1000 persisted longer than that of Salbutamol also. These findings were contrary to the effects of the same drugs used in a sample of asthmatic patients. The authors suggested that the findings of the two studies may support the hypothesis that bronchitics are more sensitive to vagal reflex action than are asthmatics.

Petrie and Palmer (1975) studied the effects of one anticholinergic and one adrenergic drug in eight patients with bronchitis and eight patients with asthma. The adrenergic drug, Salbutamol, was significantly more effective than the anticholinergic drug, ipratropium bromide, in the asthmatic subjects. No significant differences were found between the effects of either drug in the chronic bronchitis group. Specific airway conductance and forced expiratory volume in one second were the measurements used. These findings lend support to the suggestion that anticholinergic drugs are effective bronchodilator agents in the treatment of non-atopic airways obstruction such as that which often accompanies chronic bronchitis.

Klock et al. (1975) measured forced expiratory flows, specific airway conductance, airway resistance and functional residual capacity in 15 subjects with diagnoses of chronic bronchitis who were treated with atropine sulphate, isoproterenol or a placebo for three weeks. Measurements were taken 15 and 60 minutes after inhalation of the drugs. Significant increases in lung function were demonstrated both 15 and 60 minutes following inhalation of atropine sulphate and
isoproterenol. No significant differences in lung functions were demonstrable between the effects of either drug at either measurement interval. The investigators suggested the possibility that exaggerated vagal-motor tone may contribute to bronchoconstriction in chronic bronchitis.

Facilitation of Airway Clearance

Postural drainage is believed to cause movement of secretions from smaller to larger airways from which the cough mechanism can more effectively remove them. The rationale for the accompanying percussion and vibration is to dislodge mucus plugs (Foss, 1973). On bronchoscopy vibrations have been shown to squeeze secretions from smaller into larger bronchi (Thacker, 1971).

Jones and Clarke (1970) point out that a decrease in caliber exists between airways from top to bottom of the lung. They suggest that this difference may be due to the weight of the lung itself. The result is that the EPP are further upstream at the lung bases. As the EPP move to smaller and smaller airways there is a greater likelihood that the airway will close completely. Each airway generation has successively thinner walls and is, therefore, more compliant than the one preceding it. The authors recommend postural coughing in an attempt to remove secretions which might otherwise totally obstruct compliant airways.

Petersen et al. (19672 evaluated the effects of the various therapies used in the treatment of chronic bronchitis, one of which was breathing exercises. Their data revealed that patients were helped
subjectively and showed considerable clinical improvement but that there was a lack of concomitant demonstrable improvement in lung function tests.

Pavia, Thomson, and Phillipakos (1976) took a group of 10 patients with chronic bronchitis and studied the effect of an electrical vibrating pad applied to their backs for a period of one hour during which they were resting in the Fowler's position. Airway clearance was measured by movement of inhaled tracer particles and sputum expectorated. Each subject acted as his own control and was tested twice, once with and once without the vibrator pad. No significant difference was found between removal of tracer particles in either case.

March (1971) studied the effect of postural drainage on 20 patients with obstructive pulmonary disease. Prior to, and following, postural drainage treatments forced vital capacity and forced expiratory flow were measured. Sputum was collected during treatments and for 30 minutes afterwards. Following postural drainage there was no significant difference in the forced expiratory spiromgrams. Correlation between the amount of sputum produced and the changes in lung function were not significant. Percussion and vibration were not included in the postural drainage treatment.

Lorin and Denning (1971) used sputum volume as a measure to compare the effectiveness of postural drainage treatment against just coughing. Their sample consisted of 17 children with cystic fibrosis. Random assignment of initial treatment was followed by the alternative treatment on the subsequent day. Postural drainage was done for 20
minutes and included percussion and vibration. The cough session was also 20 minutes during which subjects coughed and expectorated once every five minutes. The study demonstrated the superiority of postural drainage over cough alone in terms of sputum production. All the subjects were diagnosed as having cystic fibrosis, a disease in which excessive mucus production is the main cause of airway obstruction.

Motoyama (1973) evaluated forms of therapy for 16 patients with cystic fibrosis. One of which was chest physiotherapy with postural drainage. The mode of chest physiotherapy was not specified. To measure the results of the treatment the MEFV curve was used. Statistically significant improvements in \( V_{\max} \) at 75 percent of VC were found up to 45 minutes following treatments. He concluded that postural drainage was an effective form of treatment for patients with cystic fibrosis.

Kang et al. (1974) reported their study comparing postural drainage and percussion treatments with postural drainage alone. The treatments were given in randomized sequence on successive days to 15 subjects with chronic respiratory disease. Sputum production, subjective improvement and changes in the forced expiratory volume in one second (FEV\(_1\)) were measured. Xenon\(^{133}\) scans were done. In all subjects positive results were found most often when postural drainage with percussion was the mode of therapy. The statistical significance of these improvements was not reported; however, lower portions of the lung fields more often showed improved xenon washout curves than did
the upper third of the lung. Sputum production was concluded to be too scanty to be evaluated.

Feldman (1976) studied the effect of postural drainage with percussion and vibration on a sample of nine subjects with cystic fibrosis and 10 subjects with chronic bronchitis. A pre-treatment MEFV curve was obtained from each subject. After treatment the MEFV measurements were obtained at 5, 15 and 45 minutes. Sputum was collected during the treatment and for 45 minutes afterwards. Significant increases in isovolume flow rates near 50 percent and 75 percent FVC were demonstrated which the author interpreted as indicating the effectiveness of postural drainage in mobilizing secretions from small peripheral airways. The necessity to perform numerous FVC maneuvers for the measurements themselves resulted in mobilization of secretions, wheezing and coughing. She postulated that these maneuvers alone may clear as much sputum as postural drainage.

**Maximum Expiratory Flow Volume Curves**

The MEFV curve demonstrates the relationship between $\dot{V}_{\text{max}}$ and lung volume. It is explained in terms of elastic recoil and airway resistance between the alveoli and the EPP at any given lung volume (Macklem and Mead, 1968, p. 159). Green et al. (1973) compared the MEFV curves to other pulmonary function parameters. Measurements of $\dot{V}_{\text{max}}$ varied considerably more than did those of VC and FEV$_1$, although both FEV$_1$ and $\dot{V}_{\text{max}}$ include effort dependent components which are known to vary. Both MEFV and FEV$_1$ were more sensitive at lower slopes, that
is, in disease states. Green and co-workers attempted to define the 
extent and causes of normal variability in the MEFV curve. Although 
inter-individual variability was common they postulated that the curve 
would be a useful measurement when each subject was able to act as his 
own control.

Hyatt and Black (1973) pointed out that MEFV curves do differ 
even among so-called normal individuals. Although the reason for the 
difference is not entirely understood they suggest that it is a 
reflection of non-identical mechanical properties in many lung regions. 
Other factors affecting the curve are gas density, elevation of airway 
resistance and alteration in elastic recoil.

Matsuba and Thurlbeck (1973) studied 76 lungs from 49 deceased 
patients who had a documented diagnosis of chronic bronchitis. They 
describe finding vastly greater amounts of mucus in the airways of the 
diseased lungs than could be found in normal lungs. Small airways had 
significantly narrower average diameters than those expected in normal 
lungs. As the patients had been free of pulmonary disability at the 
time of their death it was concluded that disease in small airways 
only changes total airway resistance slightly and, because their 
elastic recoil would be intact, little or no change in flow could be 
anticipated.

Gelb and Zamel (1973) measured MEFV curves and closing lung 
volumes on nine subjects with respiratory disease who had normal 
spirometry tests. Abnormal MEFV curves were demonstrated on all nine 
subjects, noticeably at low lung volumes. Their results implied that, 
in comparison to other measurement techniques available, the MEFV
curve is a more sensitive indicator of peripheral airway obstruction, particularly at low lung volumes.

Motoyama (1973) found that $V_{\text{max}}$, particularly at low lung volumes (75 percent of VC) was significantly decreased in children with cystic fibrosis even when their conventional spirometric tests were within normal limits. He stated that $V_{\text{max}}$ primarily reflects the flow resistance of the smaller airways in children with cystic fibrosis since elastic recoil pressure is normal in these children.

In 1974, Green, Mead, and Turner described within-individual variation on the MEFV curve, especially at low lung volumes. They interpreted the results of their study as suggesting that the variability of the curves was due primarily to resistance to flow rather than to the force producing the flow, that is, static recoil. They also postulated that the inherent differences in airway and parenchymal structure between individuals accounted, in part, for the impossibility of defining "normal limits" for the curve.

In 1975, Macklem reviewed the value of the MEFV curve as a test of lung mechanics. He stated that it is proving to be a sensitive indicator of early airways obstruction, it has the potential for distinguishing between peripheral airway obstruction and loss of lung elastic recoil, and that it is a relatively simple pulmonary function test to perform.

Knudson, Slatin, et al. (1976) reported a study involving 3115 subjects in which the MEFV curve was evaluated. These investigators cautioned that the value of the curve as a measure of abnormality is limited because it was found to have interindividual variability and
broad normal limits. Therefore, it was suggested that subjects act as their own controls. Furthermore, the RV/TLC ratio increases with age and determinants of RV differ with age. In the older population, the individual's ability to sustain expiratory effort diminishes, while in the younger population, significant airway closure may be prevented by a premature balance between static muscle and static recoil forces. Also, in young people, the effort dependent portion of the curve may extend beyond the first part of the curve contributing further to variability at the end of the curve. The authors suggest that composite MEFV curves are most representative of an individual's best flow and largest expired VC, and, as such, minimize intra-individual variability.

Knudson, Burrows, and Lebowitz (1976) reported that, although Vmax 75 percent appeared to be the most sensitive indicator of abnormality in their total population of 3115 subjects, if the population was subdivided into age groups this was no longer so. In subjects 35 years of age or older Vmax 75 percent was superior to the FEV1 as an indicator of abnormality. In the younger group the FEV1 was the more sensitive measurement.

Summary

Measurement of airway clearance has proved difficult and inconclusive. One method of doing so has been to measure airway mechanics by means of the MEFV curve, which is a relatively simple test for subjects to perform. Because it is thought to provide an indirect measure of changes in airway resistance it was used in this study to
evaluate the effectiveness of two forms of treatment in decreasing the degree of small airway obstruction caused by excessive secretion production.
CHAPTER 3

METHODOLOGY

An experimental research design was used to study the effects of postural drainage and deep breathing with coughing on maximum expiratory flow at low lung volumes in patients with chronic Bronchitis. The research proposal, subject consent form (see Appendix A) and physician consent form (see Appendix B) were submitted to, and approved by, the University of Arizona Human Subjects committee. A letter of approval appears in Appendix C.

Sample

Eleven subjects from a southwestern metropolitan area who had a diagnosis of chronic bronchitis participated in the study. Criteria for subject selection were:

1. Diagnosis of chronic bronchitis.
2. English speaking.
3. Determined by a physician to be physically able to tolerate postural drainage and repeated FVC maneuvers and pulmonary function testing.
4. Permission from their physicians to use an inhaled bronchodilator prior to each treatment session.
5. Willing to abstain from postural drainage for at least six hours prior to each experimental treatment session.
6. Willing to abstain from positive pressure breathing treatment, bland aerosol or aerosolized bronchodilator medication for at least four hours prior to each experimental treatment session.

7. Not requiring hospitalization for an acute exacerbation of disease during the time of their participation in the study.

Persons who met the criteria had the purpose and nature of the study explained to them and were asked if they would be willing to participate. Signed consents were obtained from subjects and from their physicians. Confidentiality was assured by assigning a number to each subject. Assurance was given to subjects that they were free to withdraw from the study at any time without affecting either their relationship with any doctor or nurse, or the quality of their treatment or care.

Each subject was requested to abstain from using aerosol or positive pressure breathing treatments for at least four hours prior to each treatment session. They were asked to abstain from postural drainage for at least six hours prior to each treatment session. Oral bronchodilator medication regimes were continued uninterrupted.

Treatment Protocols

Postural Drainage

Anterior, posterior, right and left lateral positions designed to drain basal lung segments were used (see Figure 1). Each position was assumed for five minutes, making a total of 20 minutes per treatment session. The subjects lay in each position for two minutes after
which the area being drained was percussed for one minute. The
subjects were instructed to inhale deeply for three subsequent
breaths and prolong exhalation on each occasion. During the three
prolonged exhalations the investigator vibrated the area being
drained. The subjects remained in the drainage positions for the
remainder of the five minutes.

Deep Breathing with Coughing

Subjects were required to sit in a chair for 20 minutes.
Every five minutes they were instructed to inhale slowly to TLC and,
using pursed lips, breathe out slowly to RV. The VC maneuver was
repeated three times. At the end of the third maneuver subjects were
requested to cough near RV. The subsequent deep inspiration to TLC
was followed by a series of coughs down to near RV. The investigator
did not apply any form of pressure to the subjects' chests during
this time.

Measurements

MEFV Curves

Maximum expiratory flow volume curves were obtained from each
subject prior to starting each treatment and at 20, 40 and 60 minutes
after each treatment. Flow was measured by means of a pneumotachograph
(Fleisch #4) and a differential pressure transducer (Statham PM-283TC).
Integration was done electronically to convert the flows to a volume
signal. Curves were traced from the oscillograph by the investigator
using an oscillograph. Each time an MEFV curve was required a
composite of three was recorded in order to minimize intraindividual variability. To obtain the composite curve, the three individual curves were superimposed so that the largest vital capacity and the best flows achieved at any volume could be readily determined, as described by Knudson, Slatin, et al. (1976).

Calculations of \( V_{\text{max}} \) 50 percent and \( V_{\text{max}} \) 75 percent were made from the composite curves recorded prior to each treatment. Flows on the post-treatment curves were measured at isovolume points, that is, volumes corresponding to 50 percent and 75 percent of the largest baseline expired vital capacity. Changes in \( V_{\text{max}} \) at these isovolume points were used to assess the effects of each treatment. It was assumed that TLC remained constant throughout the pre- and post-treatment periods, even though RV may have changed.

Sputum

Sputum was collected during the treatment sessions. Volume, consistency and color of the sputum expectorated by each subject during each session was recorded, as was the time during each treatment at which it was produced.

Wheezeing

The presence of wheezing, heard with a stethoscope prior to each MEFV measurement, was recorded as scattered, moderate or profuse by the investigator.
History

Information from the subjects' charts was recorded on data collection sheets (see Appendix D). For those subjects who had had pulmonary function studies done in the past their most recent studies pre- and post-bronchodilator inhalation were recorded.

Research Design

Each subject served as his own control by being exposed to both forms of treatment. The treatment order was randomly assigned. Treatment sessions were scheduled one week apart. Before the experimental sessions commenced each subject was instructed in the performance of a FVC maneuver.

Five minutes prior to obtaining the pre-treatment composite MEFV curve two inhalations of aerosolized metaproterenol were administered in an attempt to eliminate any reversible bronchial constriction which may have been present prior to treatment.

Data Analysis

Data analysis was carried out on the total sample and on two groups which were formed on the basis of degree of demonstrable reversibility of airways obstruction and documented history of asthma. Inspection of the raw data revealed no obvious patterns in terms of reduction or increase in flows at isovolume points corresponding to 50 percent and 75 percent FVC on baseline curves 20, 40 or 60 minutes following treatments. Only those flows which had changed 10 percent or more from Baseline were considered to be real changes. The decision was made to analyze all the data in terms of the change in flows from
baseline measurements to those measurements taken 60 minutes following each treatment at isovolume points corresponding to 50 percent and 75 percent baseline FVC. Hereafter these measurements will be referred to simply as post-treatment measurements.

Two-way analysis of variance (Dunn and Clark, 1974, p. 138) was used to determine if there was a significant difference between all subjects' responses to postural drainage and their responses to deep breathing with coughing when taking into consideration the random differences in baseline VC that occurred in seven of the subjects. In order to confirm the interpretation of the analysis of variance a non-parametric test, the Wilcoxon matched-pairs signed rank test (Siegal, 1956, p. 75), was used to examine, firstly, whether or not the day 1 mean baseline \( V_{\text{max}} \) measurements were the same as those obtained on day 2. Secondly, it was used to examine whether or not there were significant differences between the mean post-treatment \( V_{\text{max}} \) measurements obtained on day 1 and mean post-treatment \( V_{\text{max}} \) measurements obtained on day 2.

One-tailed Student-t tests (Mueller, Schuessler, and Costner, 1970, p. 410) were used to test for significant differences between the way in which subjects in group I (minimal reversibility of airways obstruction) responded to a treatment compared to the way in which subjects in group II (marked reversibility of airways obstruction) responded to the same treatment. The one-tailed test was used because it was presumed that subjects in group I were less likely to demonstrate adverse effects as a result of treatment than those subjects in group II. A two-tailed Student-t test (Mueller et al.,
1970, p. 416) was used to determine whether the demonstrated difference in response to treatments between the two groups was due to differences between each group's baseline flow measurements or to differences in corresponding post-treatment measurements.
CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

Characteristics of the Sample

The sample consisted of 11 subjects all of whom had a diagnosis of chronic bronchitis. Two of the 11 had the additional diagnosis of asthmatic bronchitis. The total group was made up of three females and eight males whose ages ranged from 41-82 years with a mean age of 61 years. Nine of the subjects had had pulmonary function studies done within the past two years. On their most recent studies eight subjects had demonstrable reversible components to their disease based on pre- and post-bronchodilator inhalation. One subject's spirometry worsened following bronchodilator inhalation. Two had never undergone pulmonary function testing. Subjects were assigned to two groups because of the variance in reversibility of airways obstruction.

Group I was composed of seven subjects, three females and four males, with a diagnosis of chronic bronchitis. All had a less than 20 percent change in pulmonary function following inhalation of bronchodilator medication. Four of the subjects demonstrated increases in their percent predicted FVC from one percent to 12 percent following bronchodilator inhalation. One demonstrated a three percent decrease in percent predicted FVC after bronchodilator inhalation. Two subjects who had not had pulmonary function studies done were included in group I because neither had any history of asthma.
Group II was composed of four male subjects, all of whom had a diagnosis of chronic bronchitis and of whom two had an additional diagnosis of asthmatic bronchitis. All had a 20 percent or greater improvement in lung function following bronchodilator inhalation. They demonstrated increases in their percent predicted FVC from 22 percent to 48 percent following inhalation of bronchodilators.

In Group I the subjects' ages ranged from 41-82 years with a mean age of 58.7 years. Of the seven subjects six were taking oral bronchodilators regularly, two were taking steroids. None were taking antibiotics at the time of their participation in the study. Two had the specific diagnosis of emphysema included in their medical record and one had a documented history of cor pulmonale. Based on normal values presented by Kory et al. (1961) their most recent pulmonary function studies showed that their pre-bronchodilator inhalation percent predicted FVC ranged from 53-83 percent with a mean of 69.2 percent. Following bronchodilator inhalation their percent predicted FVC ranged from 50-93 percent with a mean of 76 percent (see Table 1). Two of the seven were non-smokers, five had histories of smoking from one-half to four packs per day, two of the five smokers had ceased to smoke.

In Group II the subjects' ages ranged from 55-72 years with a mean age of 65 years. All four subjects were taking oral bronchodilator medication regularly, one was taking steroids and one was taking antibiotics. Based on normal values presented by Kory et al. (1961) their most recent pre-bronchodilator inhalation percent predicted FVC ranged from 49-77 percent with a mean of 65 percent.
Table 1. Characteristics of Subjects in Group I — Showing age, sex, height, weight, pre- and post-bronchodilator inhalation percent predicted FVC, steroid therapy, oral bronchodilator therapy, and additional diagnoses.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Sex</th>
<th>Ht. (cm)</th>
<th>Wt. (Kg)</th>
<th>Pre-bronchodilator FVC from previous pulmonary function studies (% predicted)</th>
<th>Post-bronchodilator FVC from previous pulmonary function studies (% predicted)</th>
<th>Steroids</th>
<th>Oral bronchodilators</th>
<th>Diagnosis in addition to chronic bronchitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43</td>
<td>F</td>
<td>156</td>
<td>79.75</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>41</td>
<td>M</td>
<td>175.5</td>
<td>62.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>64</td>
<td>F</td>
<td>165</td>
<td>61</td>
<td>84%</td>
<td>92%</td>
<td>-</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>57</td>
<td>M</td>
<td>185.5</td>
<td>84.8</td>
<td>75%</td>
<td>87%</td>
<td>-</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>47</td>
<td>M</td>
<td>186.75</td>
<td>97.8</td>
<td>53%</td>
<td>50%</td>
<td>+</td>
<td>+</td>
<td>Cor Pulmonale</td>
</tr>
<tr>
<td>6</td>
<td>77</td>
<td>F</td>
<td>155.5</td>
<td>44.2</td>
<td>61%</td>
<td>62%</td>
<td>+</td>
<td>+</td>
<td>Emphysema</td>
</tr>
<tr>
<td>7</td>
<td>82</td>
<td>M</td>
<td>177.5</td>
<td>77.7</td>
<td>83%</td>
<td>93%</td>
<td>-</td>
<td>+</td>
<td>Emphysema</td>
</tr>
</tbody>
</table>
Following bronchodilator inhalation their percent predicted FVC ranged from 77-110 percent with a mean of 100.25 percent (see Table 2). One of the four subjects was a non-smoker, three had histories of smoking from one to two and one-half packs per day, two had stopped smoking entirely and one stated that he had reduced the number of cigarettes smoked to six per day.

**Analysis of MEFV Curves**

Five minutes after administration of two inhalations of metaproterenol and prior to each experimental treatment, a composite of three flow-volume curves was recorded. At 20, 40 and 60 minutes following each treatment composite flow-volume curves were again recorded. Data obtained from post-treatment composite curves after postural drainage and after deep breathing with coughing were compared to baseline data taken from the FVC measured on the respective pre-treatment composite curves. Calculations of baseline Vmax 50 percent and baseline Vmax 75 percent were made from each of the two pre-treatment composite MEFV curves. Flows were calculated from the post-treatment curves using isovolume points corresponding to 50 percent and 75 percent FVC on the respective pre-treatment curves (see Figure 5).

Each subject's flows, recorded at each time period during each treatment session, are presented in Appendices E and F. Changes in flow rates of 10 percent or more were assumed to represent true changes in flow. Due to combined error inherent in the recording procedure and measurement calculations those flows which changed less than 10
Table 2. Characteristics of Subjects in Group II — Showing age, sex, height, weight, pre- and post-Bronchodilator inhalation percent predicted FVC, steroid therapy, antibiotic therapy, oral Bronchodilator therapy, and additional diagnoses.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Sex</th>
<th>Ht. (cm)</th>
<th>Wt. (Kg)</th>
<th>Pre-bronchodilator inhalation FVC from previous pulmonary function studies (% predicted)</th>
<th>Post-bronchodilator inhalation FVC from previous pulmonary function studies (% predicted)</th>
<th>Steroids</th>
<th>Oral antibiotics</th>
<th>Oral bronchodilators</th>
<th>Diagnosis in addition to chronic bronchitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>71</td>
<td>M</td>
<td>177</td>
<td>74.8</td>
<td>62%</td>
<td>110%</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>Asthmatic bronchitis</td>
</tr>
<tr>
<td>9</td>
<td>72</td>
<td>M</td>
<td>165</td>
<td>76.2</td>
<td>49%</td>
<td>77%</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>55</td>
<td>M</td>
<td>174</td>
<td>71</td>
<td>77%</td>
<td>112%</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>62</td>
<td>M</td>
<td>167.5</td>
<td>71.5</td>
<td>72%</td>
<td>102%</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>Asthmatic bronchitis</td>
</tr>
</tbody>
</table>
Figure 5. Calculation of Isovolume Maximum Expiratory Flows from the MEFV Curves -- Adapted from Feldman (1976, p. 42), with written permission from the author.
percent were considered to be essentially unchanged from baseline. Increases, decreases and no changes in flows at isovolume points corresponding to 50 percent and 75 percent baseline FVC as a response to each treatment regime in subjects in Group I are presented in Table 3. On inspection, the responses of subjects in Group I to either postural drainage or deep breathing with coughing followed no definite pattern. The general trend, however, was that the greatest number of subjects had increased flow rates 60 minutes after each treatment.

Table 4 presents equivalent data for Group II. With one exception, on one flow parameter, subjects in Group II generally responded with worsened flows following both forms of treatment on all post-treatment measurements, at every time interval. In fact, their flows progressively decreased during the 60 minutes following treatments (see Appendices E and F).

The decision was made to subject data representing the change from baseline to 60 minutes post-treatment to statistical analysis. Alterations in flows at 20 and 40 minutes post-treatment were not considered further because the sample was not homogeneous and the groups were small.

When the study was designed it was anticipated that subjects would act as their own controls. However, in seven of the 11 subjects baseline vital capacities were not identical on the two treatment days. Two-way analyses of variance were done to determine if these differences in VC were significant, because difference could have affected the
Table 3. Subjects in Group I who Demonstrated an Increase, Decrease, or No Change in \( V_{\text{max}} \) at Isovolume Points Corresponding to 50 Percent and 75 Percent Baseline FVC at Each Time and for Each Treatment (N = 7).

<table>
<thead>
<tr>
<th>Minutes after treatment</th>
<th>Treatment</th>
<th>Number of subjects demonstrating changes in ( V_{\text{max}} ) at isovolume points corresponding to 50% baseline FVC</th>
<th>Number of subjects demonstrating changes in ( V_{\text{max}} ) at isovolume points corresponding to 75% baseline FVC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>20 PD</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>DB</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>40 PD</td>
<td>3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>DB</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>60 PD</td>
<td>5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>DB</td>
<td>5</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Legend: I = increase of 10% or more from baseline \( V_{\text{max}} \). 
D = decrease of 10% or more from baseline \( V_{\text{max}} \). 
O = less than 10% change from baseline \( V_{\text{max}} \). 
PD = postural drainage. 
DB = deep breathing with coughing.
Table 4. Subjects in Group II who Demonstrated an Increase, Decrease, or No Change in Vmax at Isovolume Points Corresponding to 50 Percent and 75 Percent Baseline FVC at Each Time and for Each Treatment (N = 4).

<table>
<thead>
<tr>
<th>Minutes after treatment</th>
<th>Treatment</th>
<th>Number of subjects demonstrating changes in Vmax at isovolume points corresponding to 50% baseline FVC</th>
<th>Number of subjects demonstrating changes in Vmax at isovolume points corresponding to 75% baseline FVC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>20 PD</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>40 PD</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>60 PD</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Legend:  
I = increase of 10% or more from baseline Vmax.  
D = decrease of 10% or more from baseline Vmax.  
O = less than 10% change from baseline Vmax.  
PD = postural drainage.  
DB = deep breathing with coughing.
degree of response of each subject to postural drainage and to deep breathing with coughing.

One analysis of variance was done between Group I and Group II baseline \( \dot{V}_{\text{max}} \) 50 percent and corresponding 60 minutes post-treatment measurements for each treatment. A second analysis of variance was done between Group I and Group II baseline \( \dot{V}_{\text{max}} \) 75 percent and corresponding 60 minute post-treatment measurements for each treatment. None of the F values, for either analysis of variance, were significant, which demonstrated that random differences in pretreatment measurements did not affect post-treatment changes in either group. Furthermore, this finding demonstrated that each individual subject responded in the same way to both treatments.

As a group subjects in Group I appeared to demonstrate a different response to treatment than subjects in Group II. To test for differences in the responses between the two groups to a treatment one-tailed t tests were done. The mean differences between the postural drainage treatment session baseline \( \dot{V}_{\text{max}} \) 50 percent and corresponding post-treatment measurements for Group I (mean difference = -0.141) were significantly less than the mean differences between the same parameters for Group II (mean difference = 0.521) at the 0.05 level with a Type I error of equal to, or less than, 0.05. The mean differences between postural drainage baseline \( \dot{V}_{\text{max}} \) 75 percent and corresponding post-treatment flows for Group I (mean difference = -0.110) were not significantly less than those for Group II (mean difference = 0.185). The mean differences between the two baseline and post-treatment flow parameters for Group I and Group II during the
Deep breathing with coughing treatment sessions were significantly less for Group I on each flow parameter at the 0.05 level (mean differences = -0.222 and -0.117) than for Group II (mean differences = 0.339 and 0.258) (Table 5). Thus, Group I showed an improvement, and Group II a worsening, in both flow parameters following either treatment, as reflected in the mean differences.

Table 5. Mean Differences Between Baseline and Post-Treatment Flow Measurements for Group I and Group II.

<table>
<thead>
<tr>
<th></th>
<th>Postural drainage</th>
<th>Deep breathing with coughing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline Vmax 50%</td>
<td>Baseline Vmax 75%</td>
</tr>
<tr>
<td></td>
<td>minus post-treatment isovolume</td>
<td>minus post-treatment isovolume</td>
</tr>
<tr>
<td>N</td>
<td>Vmax</td>
<td>Vmax</td>
</tr>
<tr>
<td>Group I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean difference</td>
<td>7</td>
<td>-0.141</td>
</tr>
<tr>
<td>(Standard deviation)</td>
<td>(0.155)</td>
<td>(0.281)</td>
</tr>
<tr>
<td>Group II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean difference</td>
<td>4</td>
<td>0.521</td>
</tr>
<tr>
<td>(Standard deviation)</td>
<td>(0.790)</td>
<td>(0.213)</td>
</tr>
<tr>
<td>One-tailed Student-t test significance level</td>
<td>&lt;0.05</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>
It had been hypothesized that postural drainage would result in a statistically significant increase, at the 0.05 level, in \( V_{\text{max}} \) at volumes corresponding to 50 percent and 75 percent of the largest pre-treatment vital capacity. Findings from the two-way analysis of variance demonstrated that there were no significant differences between baseline and post-treatment measurements at either flow parameter during the postural drainage treatment sessions. Therefore, the hypothesis that postural drainage would result in increased flow rates was rejected.

Deep breathing with coughing had been hypothesized to result in statistically significant increases, at the 0.05 level, in \( V_{\text{max}} \) at volumes corresponding to 50 percent and 75 percent of the largest pre-treatment vital capacity. Findings from the two-way analysis of variance revealed no significant differences between baseline and post-treatment measurements at either flow parameter during the deep breathing with coughing treatment sessions. Therefore, the hypothesis that deep breathing with coughing would result in increased flow rates was rejected.

It had been hypothesized that there would be no statistically significant difference, at the 0.05 level, in \( V_{\text{max}} \) at volumes corresponding to 50 percent and 75 percent of the largest pre-treatment vital capacities between the two forms of treatment. Findings from the two-way analysis of variance demonstrated no significant differences between the responses of Group I to either treatment. The same was true of the responses of Group II. Therefore, the third hypothesis was accepted.
It had been hypothesized that there would be a statistically significant difference at the 0.05 level, in the changes in \( \dot{V}_{\text{max}} \) measurements following either treatment in those subjects with no previously demonstrated improvement in percent predicted FVC following bronchodilator inhalation and in those subjects with a previously demonstrated marked increase in percent predicted FVC following bronchodilator inhalation. On all flow parameters except baseline \( \dot{V}_{\text{max}} \) 75 percent and corresponding post-treatment flows following postural drainage, there were significant differences, at the 0.05 level, between the mean differences in pre- and post-treatment measurements of Group I and Group II. A two-tailed Student-\( t \) test demonstrated no significant differences between each group's mean baseline flow parameters or between the means of post-treatment flow parameters for each treatment session. Therefore the differences between Group I and Group II were concluded to be due to actual differences between each subject's baseline and post-treatment measurements and the hypothesis was accepted.

**Other Variables**

During the postural drainage treatment sessions sputum was produced by nine of the 11 subjects. The volume ranged from 1 to 20 ml with a mean of 6.59 ml. In Group I six of the seven subjects produced sputum. The volume ranged from 1 to 20 ml with a mean of 6.75 ml. In Group II, three of the four subjects produced sputum. The volume ranged from 2 to 20 ml with a mean volume of 9 ml.
During the deep Breathing with coughing treatment sessions sputum was produced by nine of the 11 subjects. The volume ranged from 1 to 20 ml with a mean volume of 9.7 ml. In Group I six of the seven subjects produced sputum. The volume ranged from 1 to 20 ml with a mean volume of 10.9 ml. In Group II three of the four subjects produced sputum. The volume ranged from 2 to 10 ml with a mean volume of 7.3 ml.

None of the subjects in either group at any time raised sputum, the consistency of which was too thick to be moved in the sputum cups. No subject had purulent sputum at the time of their participation in the study. No relationship was apparent between the volume of sputum produced and the change in flow parameters following either treatment.

In only one subject from Group I were wheezes heard at any time during the postural drainage treatment sessions. These were heard at each measurement time interval and had been absent prior to treatment. Two subjects in Group I had wheezes present prior to deep breathing with coughing treatments, but none had audible wheezes following these treatment sessions.

In Group II only one subject never wheezed during either treatment. Of the remaining three subjects, all had wheezes present prior to postural drainage, in two subjects wheezing persisted throughout the 60 minutes following treatment, in one subject the wheezes disappeared following treatment. Only one subject wheezed before and at each measurement interval following deep breathing with
coughing treatments. The remaining three subjects did not wheeze at any time during deep breathing with coughing sessions.

Two of the 11 subjects were non-smokers. Six subjects had long smoking histories prior to quitting, that is, one and one-half to four packs per day for from 20 to 45 years. Three subjects were currently smoking from six to 30 cigarettes per day.

One possible relationship existed between the presence of wheezing at any time during the treatment sessions and the volume of sputum produced. Five of the six subjects who produced less than 5 ml of sputum did not wheeze. Of the five subjects who raised 5 ml or more of sputum four wheezed at some time during the treatment sessions.

Summary

Two-way analysis of variance revealed no significant differences in the responses of individual subjects to either postural drainage or deep breathing with coughing. The changes in baseline VC from one treatment day to the next, which occurred in seven of the 11 subjects, were not shown to be significant and, therefore, did not affect the degree of response in flow parameters in those subjects.

One-tailed Student-t tests demonstrated a significant difference when the way in which subjects in Group I, who did not demonstrate a response to bronchodilator medication, responded to each treatment was compared to the way in which subjects in Group II, who demonstrated a marked response to bronchodilator medication, responded to each treatment.
CHAPTER 5

DISCUSSION AND CONCLUSIONS

The findings from this study will be compared and contrasted with those of other investigators. Physiological mechanisms which may have contributed to the findings will be suggested. The findings have clinical implications for those health professionals directly responsible for prescription and administration of the two forms of treatment under study. These implications will be outlined. Lastly, recommendations will be made for further study of the effects of the treatments on persons with obstructive lung disease.

Responses in Maximum Expiratory Flows Following Treatments

The sample will be discussed in terms of the two groups. Group I, in which subjects had a previously demonstrated minimal reversibility of airway obstruction; and Group II, in which subjects had a previously demonstrated marked reversible component to their disease.

Contrary to findings reported by other investigators (Feldman, 1976, Motoyama, 1973) there were no significant increases in post-treatment \( \hat{V}_{\text{max}} \) at isovolume points corresponding to pre-treatment 50 percent and 75 percent FVC following postural drainage treatment. Furthermore, there were no significant changes in the same flow parameters following deep breathing with coughing treatments.
Feldman (1976) reported an initial general trend toward decreased post-treatment isovolume flow rates near 50 percent FVC 5 minutes following postural drainage. At the same time, the combined sample, which consisted of nine subjects with cystic fibrosis and ten subjects with chronic bronchitis, demonstrated statistically significant increases in isovolume flows near 75 percent FVC. By 45 minutes after postural drainage statistically significant increases in Vmax were demonstrated on both flow parameters. These findings were interpreted as reflecting mobilization of secretions from small peripheral airways to large airways where they contributed to large airways obstruction 5 minutes post-treatment. After subsequent coughing and expectoration of sputum airway resistance was said to decrease as demonstrated by increased flows 45 minutes following treatment.

In the present study, even though no statistically significant changes were demonstrated in the post-treatment Vmax measurements of either Group I or Group II after each treatment certain trends were evident in each group. Flows were only considered to have increased or decreased if the change from baseline was 10 percent or more. In Group I, following postural drainage treatments, at isovolume points corresponding to 50 percent baseline FVC three subjects had increased flows and two had decreased flows 20 minutes following treatment. Forty minutes after treatment three subjects had increased flows and none were decreased. By 60 minutes after treatment five of the subjects demonstrated increased flows and none were decreased. At isovolume points corresponding to 75 percent baseline FVC three subjects had increased flows and three had decreased flows 20 minutes after
treatment. Forty minutes after treatment four subjects had increased flows and one had decreased flows. By 60 minutes post-treatment four subjects had increased flows and none had decreased flows (see Table 3).

Responses to deep breathing with coughing treatments by subjects in Group I showed similar trends. At isovolume points corresponding to 50 percent baseline FVC 20 minutes after treatment two subjects had increased flows and two had decreased flows. Forty minutes after treatment five subjects had increased flows and two remained decreased. By 60 minutes following treatment five subjects had increased flows and none were decreased. At isovolume points corresponding to 75 percent baseline FVC 20 minutes after treatment three subjects had increased flows and two had decreased flows. Forty minutes after treatment the number of subjects with increased flows was unchanged while three had decreased flows. By 60 minutes after treatment four subjects had increased flows and two were decreased (see Table 3).

In Group II only one subject ever demonstrated increased flows on either flow parameter. These flows were at isovolume points corresponding to 50 percent baseline FVC 20 minutes and 60 minutes after deep breathing with coughing treatments. Apart from this exception, all subjects had flows which had decreased or were essentially unchanged from baseline 20 and 40 minutes after each treatment. Sixty minutes after each treatment all subjects but the one exception had decreased their flows (see Table 4). It is important to note that, not only did flows decrease following treatments, but also that, during the
60 minutes following treatments during which measurements were taken the flows diminished progressively (see Appendices E and F).

Even though the trend in flow responses amongst subjects in Group I was toward improvement it was not possible, in this study, to replicate the findings of Feldman (1976) or Motoyama (1973) in either Group I or in the sample as a whole. Two factors probably contribute to this outcome. First, the sample was not homogeneous so that, in the total sample, the responses of the subjects in Group II would detract from the effects of the responses of the subjects in Group I when attempting to demonstrate significant improvements in flows. Second, Group I (N = 7) was too small to show any significant differences in flows as a result of treatments. With a larger, homogeneous sample the likelihood of replicating the findings of these other investigators would be greater.

Other Variables

Nine of the 11 subjects in the total sample produced sputum following both forms of treatment. No statistically significant relationships were found between the amount of sputum produced and changes in post-treatment flows on either flow parameter. These findings are consistent with those of Petersen et al. (1967), March (1971), and Feldman (1976) who found no significant correlations between volumes of sputum produced and changes in lung function following breathing exercises (Petersen et al., 1967) and postural drainage (March, 1971; Feldman, 1976).

Furthermore, in this study, the mean volume of sputum produced following deep breathing with coughing treatments by the total sample
was 9.7 ml which exceeded the mean volume following postural drainage which was 6.59 ml. This finding is contrary to those of Lorin and Denning (1971) who found that, in their sample of children with cystic fibrosis, postural drainage resulted in a greater volume of sputum being expectorated than did cough alone. The different findings may be, in part, the result of differences in cough techniques. Lorin and Denning simply requested their subjects to cough and produce sputum. In the present study subjects were instructed in specific maneuvers to be included in the deep breathing and coughing treatment.

Wheezing was noticed in six of the eleven subjects at some time during either or both treatment sessions. No relationships existed between the presence of wheezes and changes in $V_{\text{max}}$ seen from baseline to 60 minutes following treatments in either flow parameter. A possible relationship was suggested by the finding that wheezes occurred most frequently in those subjects who raised 5 ml or more of sputum. However, a larger sample would be needed in order to increase the size of the categories (wheezers, non-wheezers, < 5 ml sputum, ≥ 5 ml sputum) and identify the relationship more definitively.

Feldman (1976) noticed audible wheezing in some subjects at various times during her study. Statistical analysis suggested that wheezing may have affected isovolume flow rates near 75 percent FVC 45 minutes after postural drainage. No mention was made of wheezing in relation to sputum production.
Physiological Interpretations

The most striking outcome of this study was the statistically significant differences (\(<\ 0.05\) which emerged between Group I and Group II. The total sample had been divided into two groups on the basis of response to bronchodilator medication demonstrated on pulmonary function tests and on the basis of documented diagnosis of asthmatic bronchitis in addition to chronic bronchitis.

There is more than one possible cause of the difference between groups. First, Group II subjects were known to have a marked reversible component to their disease and consequently, an increased propensity to bronchospasm. Bronchospasm is induced in reactive airways by coughing (Kazemi, 1976, p. 105). Coughing involves deep inspiration followed by forced expiratory effort. In order to obtain composite MEFV curves the subjects were required to perform FVC maneuvers three times at each measurement interval. Repeated performance of such maneuvers could, of itself, have induced bronchospasm in susceptible subjects, thus negating any possible benefits gained from either form of treatment.

Second, in this study, a beta-2 adrenergic bronchodilator, metaprotelenol, was administered to all subjects prior to each treatment session. The purpose being to eliminate any bronchoconstriction which may have been present or which may have resulted from therapy. It is possible that subjects in Group II, whose flows diminished progressively following treatments, may have benefited more from administration of anticholinergic medication prior to treatment sessions. If the diminished flows were due to vagally mediated reflex
bronchoconstriction then anticholinergic medication such as atropine may have antagonized the response.

A basic assumption of this study was that the presence of secretions in airways increases resistance to flow. It was felt, after examination of the data, that increased bronchial smooth muscle tone also contributed to diminished flow rates following treatments in subjects in Group II.

The labile nature of chronic bronchitis probably explains the reason for the changes in baseline VC seen in seven of the eleven subjects from one treatment day to the next. On the day with the smaller baseline VC that subject had a greater potential for improvement than on the day with the greater baseline VC irregardless of which treatment was to be performed. It was for this reason that subjects were not used as their own controls. The best pre-treatment VC for each subject was not used as baseline data by which to evaluate all other flow measurements obtained after both treatments. To have done so would have risked committing a type II error in data analysis.

Clinical Implications

The purpose of conducting this study was to evaluate the effects of two frequently used modes of therapy for patients with chronic bronchitis. Statistically significant changes in Vmax on two flow parameters were not demonstrated following either postural drainage or deep breathing with coughing treatments. However, following both treatment sessions, subjects in Group I reported subjective improvement even though some voiced objection to performing
the repeated FVC maneuvers which, from the investigator's observation, appeared to tire them. None of the subjects in Group II voluntarily reported subjective improvement following either treatment session. They too objected to the repeated performance of FVC maneuvers which, from the investigator's observation, became increasingly tiresome for them.

During each treatment session the investigator remained with the subjects and engaged in conversations with them. The personal attention each subject received during each treatment session may have contributed to the subjective improvement reported by subjects in Group I and the continued participation, by subjects in Group II, in a study which evoked some respiratory discomfort for them.

Petersen et al. (1967) reported subjective improvement with no concomitant improvement in lung function tests, when evaluating various therapies, one of which was breathing exercises. These findings coupled with the findings of the present study raise the possibility of psychological factors overriding physiological factors and influencing an individual's perception of his own health status.

Even though the findings were not significant, the number of subjects in Group I in whom improved flows were demonstrated increased throughout the hour following each treatment. This trend is similar to that noticed by Feldman (1976). She pointed out that the beneficial effects of postural drainage may not be evident during the first 30-60 minutes after drainage. Findings from this study raise the possibility that patients receiving either form of therapy may require up to 60
minutes afterward before they experience maximum benefits from the
treatments.

The findings lend support to the contention that deep breathing
with coughing exercises are as effective as postural drainage in re-
moving secretions from airways. Five of the seven subjects in Group I
began expectorating during, or immediately after, obtaining the pre-
treatment composite MEFV curves for at least one of the treatment
sessions. They continued to expectorate in response to subsequent FVC
maneuvers. In Group II deep breathing with coughing treatments re-
sulted in expectoration during breathing exercises in three of the four
subjects. Two of the subjects expectorated while undergoing postural
drainage: One subject began raising sputum after baseline MEFV
measurements were taken at both treatment sessions. Another only
expectorated during the postural drainage treatment session after per-
forming FVC maneuvers in order to obtain MEFV curves. Feldman (1976)
observed the same tendency of FVC maneuvers to cause mobilization of
secretions and coughing.

From this study it has been possible to identify one definite
sub-group of patients within the general category of chronic bronchitis
for whom the treatments provided no obvious benefit and were possibly
even detrimental. It is important for nurses and physicians to be
aware of the effects of repeated FVC maneuvers on the lung function of
individuals with a considerable bronchospastic component to their
disease. It has also raised the question of what type of broncho-
dilator therapy would be most appropriate for this group of patients,
especially if they are being instructed in the use of deep breathing with coughing exercises.

A second purpose of this study was to evaluate the use of an objective measurement of lung function in the assessment of the effectiveness of chest physiotherapy treatments. Although the MEFV curve was a readily obtainable measure from subjects in Group I it is likely that performing repeated FVC maneuvers aggravated bronchospasm and increased airways resistance in subjects in Group II. Therefore, in individuals in whom bronchospasm plays a major role in their disease frequent measurements necessitating FVC maneuvers are not warranted.

Furthermore, the method of measuring treatment effectiveness required performance of maneuvers similar to those which were part of both forms of therapy. That is, a FVC maneuver and the requirement, during both treatments, that subjects inhale to TLC and follow that by exhaling to RV. Both maneuvers probably mobilize secretions and stimulate cough. Therefore, it is not possible to differentiate totally between the effects of one maneuver versus the other. Unfortunately, to date, the MEFV curve is probably one of the most practical measures of small airway mechanics available.

Suggestions for Further Study

This study has identified a sub-group of patients with obstructive lung disease in whom the primary diagnosis was chronic bronchitis. Other patients with obstructive lung disease have primary diagnoses of emphysema, asthma, and bronchiectasis. Similar research could provide useful information concerning the effects of both forms
of treatment on patients with bronchiectasis, a condition which requires constant efforts toward facilitating secretion removal.

Amongst subjects in Group I improved flows were being generated 60 minutes following each treatment. It would be valuable to determine the duration of the beneficial effects of the treatments on \( \dot{V}_{\text{max}} \). Further studies should measure \( \dot{V}_{\text{max}} \) at time intervals greater than one hour following treatments in order to identify the time at which flows begin to return to baseline levels. Such information would be useful when prescribing the frequency with which treatments should be performed.

Once anticholinergic drugs are available as bronchodilators it would be useful to do similar research administering anticholinergic, rather than beta-2 adrenergic, medication prior to treatments in a sample of patients with asthmatic bronchitis. Modifications should be made in the number of post-treatment measurements and the intervals at which they are recorded to avoid aggravation of bronchospasm if possible.

This study was unable to replicate the findings of Feldman (1976) and Motoyama (1973) that postural drainage improve \( \dot{V}_{\text{max}} \) at isovolume points corresponding to \( \dot{V}_{\text{max}} \) 50 percent baseline FVC and \( \dot{V}_{\text{max}} \) 75 percent baseline FVC. The study should be replicated using a sample of patients with chronic bronchitis all of whom have a minimal reversible component to their disease as demonstrated by pulmonary function testing. The basic issue of whether or not deep breathing with coughing is as effective as postural drainage in mobilizing
secretions from small peripheral airways is still pertinent and research should be continued until some answers are forthcoming.
CHAPTER 6

SUMMARY

Chronic bronchitis is a disease characterized by excessive mucus production and overburdening of the normal mechanisms for secretion removal from the airways, mucociliary transport and cough. This study was designed to evaluate the effects of postural drainage, percussion and vibration and deep breathing with coughing. Both are used as adjuncts to therapy for patients with chronic bronchitis. The purpose was to determine whether or not deep breathing with coughing was as effective as postural drainage in improving Vmax at low lung volumes. Both treatments are assumed to facilitate airway clearance, although few previous studies designed to evaluate the efficacy of either of the two modes of treatment in improving lung function are available. In this study it was assumed that clearance of secretions would decrease airway resistance. Therefore, a relatively sensitive measure of degree of airway obstruction, the MEFV curve, was used to measure the efficacy of treatments.

The sample consisted of 11 subjects with a diagnosis of chronic bronchitis. Each subject participated in two treatment sessions, seven days apart. The treatment order was randomly assigned. Composite MEFV curves were obtained five minutes after two inhalations of metaproterenol and before starting treatment. Composite curves were recorded again 20, 40 and 60 minutes following treatment.
No statistically significant changes in \( V_{\text{max}} \) were found on either of the two measured flow parameters, \( V_{\text{max}} \) at isovolume points corresponding to 50 percent and 75 percent baseline FVC, 60 minutes following either form of treatment. The 20 and 40 minute post-treatment measurements were not subjected to statistical analysis.

The most striking finding of the study was the emergence of two statistically significantly different sub-groups within the sample. Those subjects with a previously demonstrated minimal reversible component to their disease responded completely differently to the treatment sessions than did those subjects with a previously demonstrated marked reversible component to their disease. The latter group responded with progressively worsening flows at each time interval following treatments. It was felt that the repeated performance of FVC maneuvers provided increased bronchospasm in those four subjects and, therefore, masked any beneficial effects either treatment might have had.

Responses seen in this group also raise the question of which type of bronchodilator therapy may be most appropriate for such patients. Anticholinergic, rather than beta-adrenergic, medication administered prior to treatment sessions might have prevented progressive increases in bronchomotor tone.

This study was unable to demonstrate significantly improved flow rates following either form of treatment. However, a sample consisting solely of subjects with minimal reversibility of airways obstruction may have demonstrated significant improvements since the
majority of subjects in that group did respond with improved flow rates at some time following both treatments.

Findings reconfirmed the previously recognized fact that sputum volume can be misleading if measured in order to evaluate the effects of treatment upon lung function. Another contributing factor may have been that personal attention from health care personnel may give rise to patients' positive subjective perceptions of their airways functioning.

The need to answer the question of whether or not deep breathing with coughing is as effective as postural drainage with percussion and vibration in improving \( V_{\text{max}} \) at low lung volumes is still important. This study should be repeated in patients with a primary diagnosis of chronic bronchitis and also in patients with bronchiectasis. Modifications in design would be necessary before the effectiveness of treatments could be evaluated in subjects with marked demonstrable reversibility of their obstructive disease.
APPENDIX A

SUBJECT'S CONSENT

Project title: The effect of postural drainage and deep breathing with coughing on maximal expiratory flows in patients with chronic bronchitis.

I, Ray Gorringe, am conducting a study evaluating changes in breathing tests following treatment with postural drainage and following treatment with deep breathing and coughing. I plan to record the changes in your breathing test measurements after each of these treatments.

Benefits of the study will include demonstrating a way to evaluate the effects of different forms of treatment on breathing, and providing physicians and nurses with information about the effect of each treatment on breathing in patients with chronic bronchitis. The information will be used when prescribing therapy.

Your participation in this study will require a total of four hours of your time. There is no additional cost to you for your participation. Participation will involve two periods one week apart. One of these periods will consist of a twenty minute session of postural drainage during which time you will be asked to assume four different positions, each for five minutes. I shall be performing percussion and vibration on your chest in each position. You will be asked to cough after each position and you will be allowed to rest for short intervals as needed. Immediately before, twenty minutes after, forty minutes after and sixty minutes after the treatment I shall ask you to perform a simple breathing test. Each test involves performing three forceful and complete expirations into a recording device.

The second two hour period will consist of sitting in a chair for twenty minutes. Every five minutes I will ask you to take a deep breath and breathe out slowly through pursed lips. I shall ask you to do this three times. On the third breath I shall ask you to cough when you have breathed out as far as you can. I shall ask you then to breathe in deeply once more, and to cough. I shall not be touching your chest at all during this time. Immediately before, twenty minutes after, forty minutes after and sixty minutes after the treatment I shall ask you to perform the same breathing test as that to be done after the postural drainage treatment.
Five minutes before taking the first breathing test, before the treatment session is started, I shall ask you to take two puffs of Alupent inhaler. I hope that this will dilate your airways and make raising the sputum easier. Alupent is used extensively by patients with chronic lung disease and adverse effects are extremely rare when the aerosol is administered in recommended doses. Side effects which have been reported are increased heart rate and blood pressure; palpitations; nervousness; tremor; nausea and bad taste.

Since you have participated in postural drainage, deep breathing and coughing and have had the breathing test before, you are aware of the temporary physical discomforts that can occur. They include a feeling of fullness in the head; increased difficulty breathing; and tiredness. Temporary difficulty in breathing may result from positioning and/or the movement of secretions in the airways. It can be relieved by coughing up sputum and resting.

On the days of the treatment sessions I will ask you to abstain from using aerosol and positive pressure breathing treatments for at least four hours prior to treatment, and to abstain from postural drainage for at least six hours prior to treatment. Your participation also includes permitting the investigator to record pertinent information from your chart. On the day of the study I will ask you to answer a few questions about your routine respiratory therapy.

You can be assured of the confidential handling of the information obtained in this study. Your name will not be used. The information recorded will be coded and analyzed by computer.

If you decide not to participate in the study it will not change your relationship with any doctor or nurse, or effect the quality of your treatment or care. I will answer any questions you may have about the study at any time. You may withdraw from the study at any time.

If you understand what is involved and you consent to participate in this study, please sign your name below.

The nature, demands, risks and benefits of the project have been explained to me and I understand what my participation involves. Furthermore, I understand that I am free to ask questions and withdraw from the study at any time without affecting my medical care, my relationship with any institution or person.

Subject's signature: ____________________________ Date: ____________________________
I have carefully explained to the subject the nature of the above project. I certify that to the best of my knowledge the subject signing this consent form understands clearly the nature, demands, risks and benefits involved in his participation in this study. A medical problem or language or educational barrier has not precluded a clear understanding of his/her involvement in this project.

Investigator's signature: _______________________ Date: _______________
APPENDIX B

PHYSICIAN'S CONSENT

Project title: The effect of postural drainage and deep breathing with
coughing on maximal expiratory flows in patients with
chronic bronchitis.

I have given my permission to Ray Gorringe, R.N. to use
Mr/Mrs/Miss___________________________________ as a subject in her
study. She has my permission to administer 2 puffs of Alupent inhaler
to the subject prior to each experimental treatment session.

Physician's signature: ___________________________ Date: ___________________

Investigator's signature: _________________________ Date: ___________________
LETTER GRANTING APPROVAL FOR RESEARCH

July 1, 1977

Ray Gorringe, R.N.
College of Nursing
Arizona Health Sciences Center

Dear Ms. Gorringe:

Thank you for submitting a revised consent form for your project entitled, "The Effect of Postural Drainage and Deep Breathing with Coughing on Maximal Expiratory Flows in Patients with Chronic Bronchitis." The Human Subjects Committee approves this subjects at risk project effective July 1, 1977.

Approval is granted with the understanding that no changes in either the procedures followed or the consent form used (copies of which we have on file) will be made without the knowledge and approval of the Human Subjects Committee and the Departmental Review Committee. Any physical or psychological harm to any subject must also be reported to each committee.

A university-wide policy requires that all signed consent forms be kept in a permanent file in the Departmental Offices to assure their accessibility in the event that university officials need the information and the principal investigator is no longer on the staff or unavailable for some other reason. One exception is for those cases in which the subject is hospitalized or an out-patient. In such cases, the consent form may be filed with the patient's chart.

Sincerely yours,

/s/
Milan Novak, M.D., Ph.D.
Chairman
Human Subjects Committee

MN:pl

xc: Gayle Traver, R.N., M.S.N.
Departmental Review Committee
APPENDIX D

DATA COLLECTION SHEET

DATE: __________________________

TREATMENT: ________________________ TIME: ________________________

SUBJECT: ___________ ID ____________

AGE_________ WT._________ HT._________ SEX __________

DIAGNOSIS: 1) CB __________ 2) CB and Emphysema __________

3) CHF __________ 4) Cor Pulmonale __________

PHYSICAL FINDINGS: __________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

CHEST X-RAY (date ____________ ) ______________________________________________

____________________________________________________________________________

BLOOD GASES (date ____________ ) pH _____ PaO2 _____ PaCO2 _____ O2 sat. _____

HCO3_____

PULMONARY FUNCTION STUDIES (date ____________ )

Pre-bronchodilator _____________________________________________________________

Post-bronchodilator ___________________________________________________________

MEDICATIONS: _______________________________________________________________

____________________________________________________________________________

SMOKING HISTORY: ____________________________________________________________________________________________
RESPIRATORY THERAPY: Time since last bronchodilator

Time since last IPPB
Time since last aerosol
Time since last postural drainage
Time since last breathing exercises
Frequency of postural drainage at home
Duration of postural drainage at home
Frequency of breathing exercises at home

SPUTUM: Amount during experimental session, color

Consistency: 1. Thick, will not move when collection cup tipped from side to side
2. Thick, moves when collection cup tipped from side to side
3. Thin, moves freely when collection cup tipped from side to side

WHEEZING

SAMPLE # ABSENT SCATTERED MODERATE PROFUSE
1.______________________________
2.______________________________
3.______________________________
4.______________________________

MEPV CURVES

SAMPLE # \( \dot{V}_{\text{max}} 50\% \) \( \dot{V}_{\text{max}} 75\% \)
1._________________________________
2._________________________________
3._________________________________
4._________________________________
<table>
<thead>
<tr>
<th>Sample #</th>
<th>Time</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>immediately before treatment</td>
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<td>20 minutes following treatment</td>
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<td>3</td>
<td>40 minutes following treatment</td>
</tr>
<tr>
<td>4</td>
<td>60 minutes following treatment</td>
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### APPENDIX E

**BASELINE AND POST-TREATMENT VOLUME AND FLOW MEASUREMENTS TAKEN FROM EACH SUBJECT DURING POSTURAL DRAINAGE TREATMENT SESSIONS**

<table>
<thead>
<tr>
<th>Subject</th>
<th>50% Baseline FVC (l)</th>
<th>Baseline Vmax 50% (l/sec)</th>
<th>Flows @ isovolume points corresponding to 50% baseline FVC (l/sec)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>20 min post-Rx</td>
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<th>Subject</th>
<th>75% Baseline FVC (l)</th>
<th>Baseline Vmax 75% (l/sec)</th>
<th>Flows @ isovolume points corresponding to 75% baseline FVC (l/sec)</th>
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<td>20 min post-Rx</td>
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75
APPENDIX F

BASELINE AND POST-TREATMENT VOLUME AND FLOW MEASUREMENTS TAKEN FROM EACH SUBJECT DURING DEEP BREATHING WITH COUGHING TREATMENT SESSIONS

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<th>Baseline FVC (l)</th>
<th>Baseline V_{max} 50% (l/sec)</th>
<th>Flows @ isovolume points corresponding to 50% baseline FVC (l/sec)</th>
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<tr>
<th>Subject</th>
<th>Baseline FVC (l)</th>
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<th>Flows @ isovolume points corresponding to 75% baseline FVC (l/sec)</th>
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<td></td>
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REFERENCES


Traver, G. A. "Approaches to Airway Care or Sputum is Beautiful." Unpublished paper from the Division of Respiratory Diseases, University of Arizona, 1977.
