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by

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Dyspnea in the Ventilator-Assisted Patient

Mary T. Lush

Abstract

The purpose of this research was to study the occurrence of dyspnea in ventilator-assisted patients. Five alert and oriented patients (4 females, 1 male; mean age 56.4 years) with restrictive and/or obstructive pulmonary disease, receiving mechanical ventilation, participated in this descriptive study. At consistent four hour intervals and also when patients complained of dyspnea, the patients quantified the severity of their dyspnea using the visual analogue and modified Borg psychometric scales. At each measurement of dyspnea, nurses observed human and environmental fields for indices of dyschrony derived from Rogers (1980) principle of integrality and from two theories of dyspnea. There was a moderate correlation ($r = .51$, $p < .001$) between the number of events and activities at the time of dyspnea and the severity of dyspnea. Additionally, there was a weak correlation between the severity of dyspnea and arterial pCO_2 ($r = .28$, $p < .03$), static pressure ($r = .22$, $p < .02$), and minute volume ($r = -.31$, $p < .001$). The most frequent nursing actions taken in response to dyspnea were found to be suctioning, changing patient position, and bagging the patient. The visual analogue and modified Borg measures of dyspnea demonstrated a strong, positive correlation ($r = .92$, $p < .001$) supporting the concurrent validity of each instrument. The descriptive design provided

information about dyspnea in the critically ill ventilator-assisted patient. Indications for future study include evaluating the relationship between dyspnea and specific nursing activities and testing specific therapeutic interventions for relieving dyspnea during mechanical ventilation.

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Background

Dyspnea is the patient's subjective sensation of difficulty in breathing (Burki, 1980). Clinically, dyspnea is associated with pulmonary, cardiovascular, and neurological pathology, chest trauma, pregnancy, obesity, anxiety states, and extreme environmental conditions such as high altitude (Carrieri, Janson-Bjerklie & Jacobs, 1984). Dyspnea also appears to be experienced by ventilator-assisted patients. In an unpublished open-ended questionnaire survey of 34 critical care nurses, Lush (1984) found that dyspnea was observed in mechanically ventilated patients. Of the 34 nurses, 44.1% observed dyspnea in patients with chronic obstructive pulmonary disease, 29.4% observed dyspnea in patients with open heart surgery, and 23.4% observed dyspnea in patients with adult respiratory distress syndrome. Dyspnea also was observed by 8.8% of nurses in ventilator-assisted patients with pneumonia, 8.8% in patients with respiratory failure, 8.8% in patients with asthma, and by 8.8% of the nurses in patients with chest trauma. Study results showed that 32.4% of the nurses observed dyspnea in association with an increase in heart rate, 29.4% with a change in blood pressure, 29.4% with a change in patient color, while 23.5% of the nurses had seen dyspnea in association with an increase in respiratory rate. Dyspnea was also seen by 8.8% of the nurses in association with diaphoresis, 8.8% with gagging, and by 8.8% of the nurses in association with restlessness. Study results also showed

that 35.3% of the nurses perceived dyspnea to be provoked by turning or positioning of the patient. Dyspnea was also associated with weighing the patient on a bedscale by 26.5% of the nurses, with positioning of the patient flat in bed by 14.7% of the nurses, with suctioning by 11.8% of the nurses, and with manipulation of intravenous lines by 11.8% of the nurses. Factors in the environment seen by nurses as precipitating dyspnea were: family visits (20.6%), physician visits (11.8%), nurse visits or activities (8.8%), and increased noise or activity (5.8%). Twenty-one percent of the nurses responded that there were no environmental factors associated with dyspnea. The study also showed that 26.5% of the nurses responded to episodes of dyspnea by "bagging" the patient, 26.5% responded by providing reassurance, 14.7% responded by sedating the patient, 14.7% responded by helping patients to relax, and 11.8% of the nurses responded to dyspnea by changing ventilator settings.

In a survey of pulmonary physicians (N = 6), Lush (1984) found that they also had observed dyspnea in ventilator-assisted patients. Factors reported by the physicians as producing dyspnea in mechanically ventilated patients included anxiety, hypoxia, hypercapnia, low tidal volumes, high tidal volumes, high or low flow rates, activation of type "J" receptors, decreased compliance, obstruction, increased interstitial pressure, increased airway resistance, loss of physiologic positive end expiratory pressure, and either high or low ventilator rates.

Ventilators are used extensively in the critical care setting. Patients with apnea, hypercapnic respiratory failure, cardiovascular collapse, right to left shunting pathology, and severe diffusion defects require ventilatory assistance (Shapiro, 1975). In an average 500 bed hospital, approximately 150 patients per year are mechanically ventilated for respiratory failure (Bushnell, 1979). Additionally, about 63,000 patients per year who undergo surgery for cardiac revascularization or valve repairs are placed on mechanical ventilators for cardiopulmonary support during the initial postoperative period (Department of Health and Human Services, 1982)).

Clinical experience suggests that ventilator-assisted patients experiencing dyspnea are uncomfortable and require intensive nursing care such as frequent manual respiratory assistance ("bagging") and constant reassurance by the nurse. Anecdotal observations also suggest that patients who experience severe dyspnea during mechanical ventilation have difficulty being weaned from the ventilator resulting in a prolonged weaning period. This difficulty may extend hospital admissions and increase the cost of health care. Prolonged ventilatory assistance also increases the risk of intrapulmonary infection (Elliott, Morris, & Mortensen, 1985) and is associated with increased mortality (Schachter, Polli, Livingston, Beck & Witek, 1985). Other risks superimposed by extended periods of positive pressure mechanical ventilation include peripheral pulmonary hypoventilation resulting in

atelectasis, impaired hemodynamic function secondary to increased intrathoracic pressure, and development of peripheral edema and engorgement of the portal system due to impaired venous return (Rau, 1981; Vincent, 1983; Sladen, Laver, & Pontoppidan, 1968).

Although dyspnea has been observed in ventilator-assisted patients, the incidence and genesis of dyspnea have not been reported in the literature. Since there is a paucity of information about dyspnea in this patient population, and an absence of a theoretical basis for the interventions used to decrease dyspnea, nursing care to control dyspnea in the ventilator-assisted patient is being rendered on an intuitive basis. This research study will initiate a data base for the scientific development of nursing interventions for ventilator-assisted patients experiencing dyspnea, and contribute to the body of knowledge of dyspnea.

In summary, dyspnea has been noted by critical care nurses and pulmonary specialists to occur in ventilator-assisted patients, but little is known of its incidence, or variables related to its etiology. Therefore, nurses have an insufficient knowledge base to explain, predict or control the phenomenon. Description of dyspnea in ventilator-assisted patients may enable nurses to assess, delimit and control factors influencing dyspnea in these critically ill patients.

Purpose

The purposes of this study were to describe conditions under which dyspnea occurs in ventilator-assisted patients and responses to it.

Specific Aims

Specific aims of the study were:

1. To describe characteristics of patients who experience dyspnea while receiving mechanical ventilation (i.e. age, gender, diagnosis, pulmonary pathology);

2. To identify human field indices of dyspnea;

3. To describe environmental field indices of dyspnea;

4. To describe nursing responses to dyspnea;

5. To establish concurrent validity of the visual analogue and modified Borg scales, as measures of dyspnea, experienced by ventilator-assisted patients in the critical care setting.

CHAPTER II

Conceptual Framework and Review of Literature

Conceptual Framework

This study was conceptualized using Roger's conceptual framework for nursing practice. In her framework, Rogers (1980, 1984) states that man and the environment are open system energy fields that are in continual interaction. Interaction between the two fields results in new, developing, increasingly diverse patterns within each field. Interactions within and between human and environmental energy fields are explained by the principles of integrality, helicy, and resonancy.

Of interest in this study is the principle of integrality. This principle states that because man and the environment are continuous, mutual, reciprocal fields, they must be examined in concert with each other. Assessment directed by this principle means that, in episodes of dyspnea, nurses need to obtain objective and subjective measures of disturbances in the human field and look for patterns in the environmental field which are associated with these disturbances. Interventions directed by this principle involve the repatterning of human and environmental fields to maximize symphony (that is, promote harmonious interaction between environmental and human fields) when usual patterns are disrupted. A successful outcome of nursing care using this principle is the patient's perception of a reduction in disharmony or dyspnea.

Review of the Literature

Human field indices which may be associated with dyspnea in the mechanically ventilated patient, were derived from two theories of dyspnea presented in the literature. These theories suggest dyspnea may be caused by excitation of pulmonary neural and chemoreceptors, or by mechanical inappropriateness.

Excitation of Pulmonary Neural and Chemoreceptors

Theory.

The excitation theory suggests that intrapulmonary neural receptors, including the stretch, irritant, and type "J" receptors, are involved in the sensation of dyspnea. Stretch receptors are located throughout the bronchial smooth muscle of the lungs (Burki, 1980). The main reflex effect of stimulation of stretch receptors is a decrease in respiratory frequency caused by an increase in expiratory time, which is known as the Hering-Breuer reflex (West, 1985). Stretch receptors act to limit inspiration at tidal volumes of 800 cc and above. Irritant receptors are branched nerve endings located in the epithelium of the airways. These receptors are stimulated by dust, chemicals, contraction of bronchial smooth muscle, and large and sudden changes in lung volume (Widdicombe, 1979a). Irritant receptors are also stimulated by conditions which decrease lung compliance, such as pulmonary congestion and pulmonary emboli (Widdicombe, 1974). Reflex effects from stimulation of irritant receptors include bronchoconstriction and hyperpnea (West). Type "J"

receptors, thought to be located in the alveolar interstitium or adjacent to the pulmonary capillaries, are stimulated by pulmonary congestion and microembolism (Widdicombe and Sterling, 1970). Stimulation of type "J" receptors can result in rapid shallow breathing; intense stimulation can cause apnea (West).

According to the intrapulmonary neural receptor theory, dyspnea in the mechanically ventilated patient may be associated with large changes in tidal volumes or with irritation of the airways. Large tidal volumes occur when ventilator volumes are excessive, or during "bagging" for pre- and postsuctioning hyperventilation. During "bagging", tidal volumes of up to 1240 cc have been shown to be delivered with a manual resuscitator (NARCO, 1978). Clinical experience also suggests that delivery of erratic tidal volumes may be associated with dyspnea. Other precipitants of dyspnea may be procedures or conditions irritating to the airway, such as excessive secretions, tracheal intubation, tracheal irrigations with normal saline, suctioning, and episodes of laryngospasm or bronchospasm. The neural receptor stimulation theory also suggests that patients with increased pulmonary congestion and/or resistance may experience dyspnea.

Standard measures of increased resistance in the critically ill mechanically ventilated patient are static pressure and peak inspiratory pressure (Gottfried, et al., 1984). Static pressure, a measure of the elastic recoil of

the lung and chest wall (excluding the airways) increases as the compliance of the lung decreases (Shapiro, 1975). Peak pressure, a measure of dynamic compliance, increases as the compliance of both the airways and the lungs decrease. Static and peak inspiratory pressures were recorded in this study as possible indices of dyspnea in the mechanically ventilated patient.

Another theory suggests that excitation of the central and peripheral chemoreceptors are important in the genesis of dyspnea. Peripheral chemoreceptors are located in the carotid bodies and respond primarily to decreases in arterial oxygen tension (pO2) and secondarily to increases in carbon dioxide of cerebral spinal fluid (West, 1985). When these receptors are stimulated, an increase in respiratory rate and/or tidal volume occurs. In patients on mechanical ventilation, this increase in ventilation is measured by exhaled minute volume (VE). Theoretically, an increase in ventilation may be associated with dyspnea although the precise mechanisms are unclear. It is unknown whether the afferent pathways have a direct dyspneic sensory input to the brain or act indirectly via the respiratory muscles (Widdicombe, 1979b).

A review of the literature since 1917, shows little demonstrated relationship between dyspnea and blood gas disturbances (Fishman and Ledlie, 1979). A possible explanation for the poor correlation observed is the wide variation in arterial pO2 seen in critically ill patients.

Thornson, Marini, Pierson, and Hudson (1979), obtained arterial pO_2 measurements every 10 minutes for 1 hour in 19 consecutive intensive care patients. Without observable clinical changes, the arterial pO_2 varied by 9% $\pm$ 3% in awake patients without head injuries, and 20% $\pm$ 7% in patients with depressed mental status.

Empirical research.

Patterson, Mullinax, Bain, Kreuger, and Richardson (1962) studied dyspnea in a patient with complete respiratory paralysis due to anterior poliomyelitis. The patient was ventilated with a Drinker (external) respirator at a rate and depth of breathing which were comfortable and resulted in normal arterial blood gases on room air. Within 90 seconds of the initiation of an inspired gas mixture of 7% carbon dioxide, the patient experienced an unpleasant respiratory sensation later verbalized as "breathing not quite so easy...smothering feeling in top part of chest..." There were no simultaneous changes in movements of the lungs or chest wall while the patient was dyspneic. Fishman and Ledlie (1979) suggested that in this case chemical changes contributed to the sensation of dyspnea via their effect on chemoreceptors or through modifications of signals in one of the neural pathways to the brain. This analysis supports the chemoreceptor theory of dyspnea. Fishman and Ledlie suggested that although arterial blood gas disturbances do not correlate well with dyspnea, they may, in some circumstances, play a role.

Mechanical Inappropriateness

Theory.

Studies by Campbell and Howell (1963, 1966) led to the formulation of the "length-tension inappropriateness theory", which states that the significant factor in the perception of dyspnea is the relationship of the pressure (tension) generated by respiratory muscle contraction and the tidal volume (change of muscle length) that results. Disparity between tension in the muscle and change in length results in misalignment of fibers in the muscle spindles of intercostal muscles. The spindles, acting as neural integrators, transmit signals that bring an awareness of breathing to a conscious level. This theory was later modified to include parameters other than just length and tension, such as abnormal movements of the chest during the phases of respiration (Campbell, 1974). In many forms of clinical dyspnea, afferent input from respiratory muscles, inappropriate for the actual work performed, seems to be the major input for the unpleasant sensation (Widdicombe, 1979b). The theory of "length-tension inappropriateness" was later called "mechanical inappropriateness" and is currently the most favored explanation of dyspnea as it considers the complex nature of the symptom. Dyspnea is assumed to result from the sensed disparity between the performance of the respiratory apparatus and a given drive to breathe (Campbell, 1974). The major tenets of this theory continue to be studied and the findings have supported the principles

hypothesized in the original theory (Campbell, Freedman, & Smith, 1961; Wiley & Zechman, 1966; Burki, Mitchell, & Chaudhary, 1978).

In the mechanical inappropriateness theory, the index of length is volume, and the index of tension is pressure (Campbell & Howell, 1966). Volume and pressure are related by the concept of compliance, defined as the ratio of the change in volume to the change in pressure (Murray, 1976). Compliance, or the distensibility of the lung, is decreased in disease processes that stiffen the lungs (atelectasis, pulmonary edema, pneumonia), in process that reduce the intrathoracic space (pleural effusions), and in conditions which mechanically restrict the chest wall (obesity, kyphoscoliosis, abdominal distention) (West, 1982). Decreased compliance increases the work of breathing (Shapiro, 1975). In ventilator-assisted patient, volume can be measured by the tidal volume (the volume of gas delivered to the patient) and by exhaled minute volume (VE) (the volume of exhaled gas over one minute). In the mechanically ventilated patient, pressure can be quantified by the peak inspiratory pressure (PIP) and static inspiratory pressure (SIP). PIP, measured at the end of inspiration when flow is present, represents both the airway resistance and pulmonary compliance that must be overcome to inflate the lung (Rau, 1981). SIP, obtained through occlusion of the airway at the end of mechanical lung inflation, is a very common method to measure the static compliance and total flow resistance of

the respiratory system in mechanically ventilated patients in respiratory failure (Rossi et al., 1985). Both volume and pressure parameters were assessed in this study to examine which of these parameters may be related to dyspnea in the mechanically ventilated patient.

The theory of mechanical inappropriateness is extended further by studies of respiratory muscle fatigue. Respiratory muscle fatigue may contribute to the development of dyspnea by compromising the ability of muscles to generate adequate force for ventilation. The diaphragm is the most important muscle of ventilation. Diaphragmatic fatigue might be expected to contribute to a perceived increase in effort resulting in the sensation of dyspnea. The etiology of diaphragmatic fatigue is currently the object of intense study (Agostoni, 1963; Guz, 1979; Campbell, 1974; Rossi, et al., 1985, Rochester, Braun, & Laine, 1977; Murciano, Lecocguic, Aubier, Viires & Pariente, 1985; Bellemare & Grassino, 1982; Sharp, Danon, Druz, Goldberg, Fishman, & Machnach, 1974; Cohen, Zagelbaum, Gross, Roussos, & Macklem, 1982). Fatigue is defined by Edwards (1979) as "a failure of the muscle to maintain or reattain the required or expected force with continued or repeated contraction" (p. 81). Fatigue may result from lack of central neural drive or from a decrease in the number of contracting muscle units. Diaphragmatic fatigue also may originate from failure of the operating muscle due to impaired neuromuscular transmission and contractile failures (Edwards). Clinical evidence of

diaphragmatic fatigue in the mechanically ventilated patient includes an increase in respiratory rate, respiratory alternans, abdominal paradox, and increased partial pressure of carbon dioxide in arterial blood (pCO2) (Cohen, Zagelbaum, Gross, Roussos, & Macklem)

To study diaphragmatic fatigue and associated respiratory sensations, Ward and Stubbing (1985) recorded dyspnea using the modified Borg scale in five normal subjects before and after respiratory muscle fatigue was induced by inspiratory resistance loading. At equivalent levels of exercise, the subjects demonstrated statistically significant ($p < .05$) increases in dyspnea during the muscle fatigue trials in comparison to prefatigue trials. The severity of dyspnea experienced by subjects in this study was not reported.

The relevance of studies which induce respiratory fatigue to chronically or acutely ill patient populations is unclear. Henson, Gillen, and Levine (1985) studied the relationship between diaphragmatic fatigue and the termination of dyspnea-limited exercise in normal males ($n = 5$). All subjects terminated the exercise protocol due to dyspnea. However, for 60% of the subjects, diaphragmatic fatigue (determined by bilateral nerve stimulation and diaphragmatic electromyogram changes) occurred prior to the termination of their exercise because of dyspnea. In contrast, six patients with chronic obstructive pulmonary disease (COPD) (FEV1/FVC 44 $\pm$ 3%) all terminated dyspnea-

limited treadmill exercise prior to the development of diaphragmatic fatigue (Levine, Gillen, Rossi, Barnard, & Weiser, 1984). Patients with COPD are considered at risk to develop contractile muscle failures because the force used to generate inspiration requires a higher percentage of their maximal inspiratory force than in subjects without pulmonary pathology (Bellemare & Grassino, 1983). Murciano, et al. (1985), examined diaphragmatic fatigue in critically ill patients and found COPD patients receiving mechanical ventilation (n = 4) had impaired diaphragmatic function as compared to ventilator-assisted patients (n = 4) without pulmonary disease. No discussion of the presence or absence of dyspnea was included. Direct documentation of diaphragmatic fatigue is not practical in the clinical setting since it requires placement of an esophageal transducer, an invasive procedure, and electromyography equipment.

Empirical research.

A thorough literature review yielded few studies addressing dyspnea in the ventilator-assisted patient. Smith, Brown, Toman, & Goodman (1947) studied the effects of intravenous d-tubocurarine on mentation in a healthy human subject. The subject was intubated and ventilated with a rebreathing bag. Unexpectedly, sensations of shortness of breath and choking were reported by the subject at certain times during the paralysis. The dyspnea was absent in the presence of the smooth pressure and release of the breathing

bag at the rate of 24 compressions per minute. At rates of 18 to 20 compressions per minute, and when the release of the breathing bag was abrupt, dyspnea recurred. This early study suggests that despite passive chest wall movements, a feeling of inadequacy of respiratory movement occurs when rhythmic breathing is not maintained, resulting in dyspnea. These results could be supportive of the mechanical inappropriateness theory of dyspnea.

Plost and Campbell (1984), reported on the work of breathing through standard #7, #8, and #9 endotracheal tubes at varied minute ventilations in four healthy subjects. The difference between esophageal pressure and pressure at the end of the endotracheal tube was calculated as the transpulmonary pressure. A breath by breath analysis of flow and transpulmonary pressure was made by a respiratory integrator. The authors concluded that for a given endotracheal tube the work of breathing increases with increasing minute ventilation. Additionally, the work of breathing at a given minute ventilation is increased by decreasing the endotracheal tube size. Endotracheal tubes did not add to the work of breathing at minute ventilations of less than or equal to eight liters per minute.

According to the Plost and Campbell study (1984), endotracheal tube size and increasing minute ventilation could be factors in the genesis of dyspnea in ventilator-assisted patients. Work is defined as force multiplied by the distance moved, and in the lungs, pulmonary pressures

represent force and pulmonary volumes are an expression of distance (Shapiro, 1975). So, increases in pulmonary pressure or volume are related to an increased work of breathing. A narrowed airway (present with an endotracheal or tracheal tube) increases resistance to flow by the fourth power of the radius of the airway (Murray, 1976). An airway with increased resistance requires a greater pressure (greater work) to deliver a given volume (Shapiro). An increase in the work of breathing, inappropriate for a given tidal volume, may result in dyspnea according to the mechanical inappropriateness theory. Shapiro (p. 103) states dyspnea is the "most sensitive and reliable indicator" that an acute change in the work of breathing has occurred.

Rochester, Braun, and Laine (1977) recorded the electrical activity from the diaphragm and accessory inspiratory muscles using esophageal electrodes in eleven ambulatory hospitalized patients prior to and during trials in an "iron lung" tank respirator. Results of two typical patients were particularly noted, including a patient with severe chronic obstructive pulmonary disease, chronic hypercapnia and hypoxemia, and cor pulmonale, and a patient with kyphoscoliosis with cardiorespiratory failure. In both patients an abrupt decrease in diaphragmatic activity, nearly to zero, occurred as soon as the tank motor was started. The patients were mildly dyspneic at rest, were more dyspneic when supine, and became free from dyspnea at the same time as diaphragmatic electrical activity had ceased. The authors

concluded the sensation of dyspnea in these patients was a result of increased diaphragmatic energy expenditure.

Summary

Little empirical research exists describing dyspnea in mechanically ventilated patients. Research using normal subjects where dyspnea is artificially produced, is difficult to generalize to patients with dyspnea during mechanical ventilation. Several studies indicate that fatigue of respiratory muscles may be an important variable related to dyspnea (Henson, Gillen, & Levine; Ward & Stubbing; Rochester, Braun, & Laine). These studies appear to support mechanical inappropriateness, currently the most favored theory of dyspnea.

CHAPTER III

Methodology

Definitions

Severity of dyspnea: A human field disturbance (change in pattern) characterized by a subjective perception of shortness of breath, or difficulty in breathing as quantified by the visual analogue scale (VAS) (Carrieri and Janson-Bjerklie, 1984) and a modified Borg scale (MBS) (Burdon, Juniper, Killian, Hargreave, & Campbell, 1982).

Ventilator: Bourns BEAR-1 volume-cycled respirator.

Ventilator-assisted patient: A patient in a critical care unit receiving ventilator delivered, predetermined volumes via an endotracheal or tracheal tube.

Human field indices: Physiological variables possibly related to the human field disturbance of dyspnea including: patient's peak inspiratory pressure (PIP), static pressure, respiratory rate, tidal volume (TV), exhaled minute volume (VE), adventitious lung sounds, and arterial blood pH, arterial oxygen tension (pO_2), and arterial carbon dioxide tension (pCO_2).

Compliance: An expression of the elastic recoil properties of the lung and chest wall, reflects the change in pressure that occurs with a given change in volume (Murray, 1976). In the mechanically ventilated patient, compliance of the entire lung (including airways) is measured by peak inspiratory pressure, while the compliance lung and chest wall (excluding airways) is measured by static inspiratory

pressure.

Peak inspiratory pressure (PIP): The highest pressure (in centimeters of water) developed during lung inflation as measured by the ventilator and displayed on the pressure dial.

Static inspiratory pressure: The pressure (in centimeters of water) required to maintain lung inflation at the end of a one second airway occlusion while the lungs are motionless, as measured by the ventilator and displayed on the pressure dial.

Exhaled minute volume: Liters of exhaled gas per minute during mechanical ventilation (VE), as measured by the ventilator.

Adventitious lung sounds: The presence of crackles, rhonchi, or wheezes in the patient's lung field as auscultated by the patient's nurse using a stethoscope.

Environmental field indices: The environment is a four dimensional energy field surrounding the patient as measured by patterns of noise, light, nursing activities, personnel, family, machinery, other patients, and unit activities reported by nurses at the time of dyspnea.

Assumptions

In this study, it is assumed that:

1. That psychometric scales quantify dyspnea.

2. The nurse will accurately observe all human and environmental field indices present at the time of data collection 100% of the time.

Design

A descriptive case-study approach was used to study dyspnea in ventilator-assisted patients. Data was collected at four hour intervals, and at patient complaint of dyspnea. Data collection ended at the completion of the weaning period, or after a maximum of ten consecutive days of data collection.

Setting

The research was conducted in two intensive care units. The first was a six bed critical care unit of a private, 99 bed, acute care hospital (Hospital A). The unit was staffed by 19 registered nurses whose experience in the care of the critically ill varied between 3 and 13 years. The staff were interested and willing to participate in the proposed study. The second setting was an eleven bed intensive care unit in a 420 bed nonprofit hospital (Hospital B). The 40 registered nurses staffing the unit had 1 to 15 years experience caring for the critically ill. These nurses also expressed great interest in participating in data collection.

Sample Criteria

Ventilator-assisted patients invited to participate in the study included those 18 years of age or older, alert, oriented, and English speaking. Patients were required to demonstrate understanding of the VAS and MBS by return demonstration. Additionally, patients were required to demonstrate visual and motor coordination: the ability to place a mark on the VAS and MBS in the intended location.

Finally, patients were able and willing to give informed consent.

Sample

The convenience sample of five patients receiving mechanical ventilation in two hospitals included 4 females and 1 male, whose age ranged from 34 to 79 years with a mean age of 56.4 years. The primary admitting medical diagnoses of the sample included hematemesis complicated by respiratory arrest (n = 1); multiple lobe pneumonitis right lung and mesothelioma right pleural cavity with recurrent pleural effusions (n = 1); respiratory failure secondary to Pickwickian syndrome (n = 1); respiratory failure with underlying COPD and chronic anxiety syndrome (n = 1); and respiratory failure complicated by bronchitis and bronchospasm (n = 1).

The breathing pathologies as documented by pulmonary function tests were severe obstructive disease (n = 1), moderate restrictive disease (n = 1), and a combination of severe restrictive and obstructive diseases (n = 1). There were no pulmonary function tests available for two of the patients. Both of these patients were morbidly obese, and the primary breathing pathology was assumed to be restrictive.

Five patients who met subject criteria were not entered into the study. One patient was not asked to participate in the study since her primary admitting diagnosis of suicidal ideation was thought to pose too severe a threat to the

validity of her results. Three male patients were invited to participate but refused. Each of these patients was in a period of anger over their respective diagnosis of respiratory failure precipitated by misuse of medications, inoperable metastatic abdominal cancer, or ruptured abdominal aortic aneurysm. A fifth patient was invited to participate, but was unable to demonstrate understanding of the VAS. This patient utilized the 100 millimeter line to write "emphysema", or more frequently, "Valium".

Instruments

Modified Borg Scale

The modified Borg scale (Borg, 1970) is a categorical scale developed to assess perceived intensity of breathlessness in relation to pulmonary function parameters. The scale is aligned vertically, with discrete, evenly spaced numerical divisions from 0 to 10 (Appendix A). Each numerical interval is marked with a verbal description of graded intensity.

Visual Analogue Scale

The VAS in this study is a 100 mm horizontal line, anchored at one end with the words "No difficulty breathing" and at the other end by the words "can't breathe" (Appendix B). Concurrent validity of the VAS has been previously demonstrated with a category rating scale in a study examining the effects of analgesia on pathological pain (Woodfore & Merskey, 1971). The correlation was highly significant ($r = +.81$, $p < 0.001$).

Demographic Data Instrument

The demographic data tool (Appendix C) was designed to facilitate the recording of the patient's past medical history and demographic data.

Field Indices Data Instrument

The field indices data instrument grouped human and environmental field indices thought to be associated with dyspnea onto one card (Appendix D). The instrument included those indices listed under the definitions of the human and environmental fields in addition to including spaces for date, time, ventilator settings, lung sounds, and chest x-rays.

Data Collection Instrument

The data collection instrument consisted of a spiral bound log book of 5 by 8 inch index cards. Log books were assigned to each patient and identified by a code number. A large rubber ink stamp was made of each instrument, including the VAS and MBS, the demographic data tool, and the data collection instrument. The first page was stamped with the demographic data tool, and the remaining pages sequentially stamped with the data collection instrument and dyspnea scales. The data collection instrument was placed first, followed by either the VAS or the MBS. The order of the scales was determined by random assignment. The VAS was arbitrarily coded as odd, and the MBS as even. A table of random numbers was used to determine placement of the scales in the log book. The numbers in the table were followed

sequentially. If the first numeral of the number was odd, the VAS was placed first, and if the first numeral was even, the MBS was placed first.

Reliability

An attempt was made to increase the reliability of the measurement of dyspnea by the use of both VAS and MBS scales, which in this study were strongly related. The random assignment of the VAS or MBS scales to the first position in a data collection set, in combination with a high correlation between the VAS and MBS scales, strengthened the reliability of the VAS and MBS scales for measuring dyspnea in the critically ill ventilator-assisted patient.

Patients did not have visual access to one scale while completing the other; or access to prior data sets when completing the current set. This minimized the potential development of response sets by patients.

The reliability of the VAS and MBS scales also depends on the visual-motor coordination of the patient, the ability to place a mark on the scale in the intended location. If the patient was mechanically unable to complete the assessment tools, the nurse completed the VAS and MBS scales for the patient by moving his/her finger along the VAS or MBS until the patient motioned to the nurse to make a mark. The mark was accepted by the nurse if the patient indicated acceptance of the location of the mark.

An attempt was made to control for interrater reliability by conducting four training sessions for nurses.

Staff nurses participating in data collection from both hospitals attended sessions describing the goals, objectives and requirements of the study. The training sessions, held in conjunction with the regular monthly staff meetings, were conducted after receiving study approval from the human subjects review board, and prior to data collection. Each nurse was given a copy of a two page detailed description of the desired sample, procedure, requirements of the hospital institutional review board, and examples of data and observations of importance to note (Appendix E). The researcher's 24 hour phone numbers were made available to the staff, with encouragement to telephone whenever potential subjects were admitted to the unit, or with any questions or concerns which should arise. Nurses unable to attend the staff meeting were oriented to the study on an individual basis. The researcher was available to patients and nurses on a daily basis for consultation.

When a patient was complaining of symptoms other than dyspnea at the time of data collection, patients were reminded by the nurse to record only the severity of dyspnea he/she was experiencing. In fact, the patients did seem to distinguish dyspnea from sensations such as pain and nausea (these sensations did not increase the severity of dyspnea above the mean severity of dyspnea for that patient).

Validity

To strengthen the validity of the instruments, in addition to every four hour data collection, the study

protocol required additional data sets to be completed at patient complaints of dyspnea. The patient's nurse reminded the patient at the beginning of each shift to notify the nurse of the occurrence of dyspnea.

The content validity of the field indices instrument used in the study was addressed by developing and selecting human and environmental field indices from the conceptual and theoretical framework.

Procedure

The nurses notified the researcher when potential subjects arrived in the critical care unit. Before approaching the patient, the chart was reviewed, and permission obtained to approach the patient from the patient's primary and pulmonary physicians.

The researcher provided a thorough explanation of the nature, purpose, risks, and requirements of the study to participating subjects and verified understanding of the same. Potential risks to the patient included the invasion of privacy, inconvenience, and the possibility that awareness of the symptom of dyspnea could augment his/her distress. Signed informed consent was obtained from the subjects.

At four hour intervals, and at patient complaints of dyspnea, the dyspnea tools were administered to the patient and human and environmental field data recorded by the patient's nurse. The nurse collected ventilator data and recorded indices of the human and environmental fields while the patient completed the assessment tools. Data which

required the repositioning or interruption of the patient (such as auscultation of lung sounds), were obtained after patient completion of the scales.

Exceptions to the above protocol occurred if the patient's condition required repositioning prior to tool administration for either patient comfort or safety, if the patient condition precluded the administration of the tools, or upon patient request to delete part or all of the dyspnea assessment tools during a particular assessment period.

An unstructured interview was conducted with each patient during the study. The interviews were held within 24 hours of extubation. The interviews were necessarily limited by hoarseness commonly associated with extubation. Questions were directed to determining whether the ventilator itself contributed to dyspnea, the patient's severity of dyspnea at the time of the interview, the patient's "usual" severity of dyspnea, and individual preference for the VAS or MBS scale, if any. The patient was also requested to identify the worst dyspnea experienced during mechanical ventilation, and what, if anything, helped to relieve it.

Data Analysis

Descriptive statistics were used to describe the sample and to analyze human and environmental field indices. The Pearson Correlation Coefficient was used to determine the level of correlation between human and environmental field indices and the intensity of dyspnea. An alpha level of .05 was the accepted level of significance.

Limitations

The reliability of the VAS and MBS in measuring dyspnea is difficult to establish since dyspnea is an unstable, subjective symptom that varies from moment to moment. Therefore, test-retest of dyspnea was not conducted.

This study required the observation by the nurse of multiple indices of the human and environmental fields. Additionally, the twenty-four data hour collection protocol and the duration of the study resulted in many nurses participating as data collectors (n = 16 in Hospital A, n = 11 in Hospital B). Therefore interrater reliability was a threat to the human and environmental field indices instrument.

Missing and incomplete data sets are also a limitation of the study. During the time a patient was entered in the study, data collection was interrupted several times in each patient due to request of the patient, a change in patient condition, or other nursing priorities in the unit. The shortest interruption in the study was two hours, and the longest 74 hours.

Additional limitations of the study include the lack of control for extraneous variables including demographic characteristics, physical and psychosocial variables, medications, or for characteristics of the patients' pulmonary and other disease states.

The design and protocol of the study provide additional limitations. The number, experience, and skill level of the

nurse data collectors were not controlled. Lack of knowledge of the duration and effect of environmental indices limit the ability to analyze the data. Additionally, all human and environmental field indices present at the time of data collection may not have been observed and/or recorded by the nurse. In 65.2% of the data sets, one or more indices were not addressed or recorded by the nurse. It is unclear whether sections of an instrument were left blank because there were no data to record, or whether data were available, but not recorded.

Finally, the size and unique characteristics of the sample also were major limitations in this study. Five patients were nonrandomly selected from two hospitals. Criteria for admission into the study eliminated many ventilator-assisted patients from consideration. Fifty percent of those invited to participate elected not to participate. The findings of this study, therefore, should not be generalized to other populations.

Results

Characteristics of Patients Experiencing Dyspnea

All patients participating in the study experienced dyspnea at some time during mechanical ventilation. Characteristics of the sample are displayed in Table 1. Breathing pathologies documented by pulmonary function tests included restrictive (1), obstructive (1), and mixed restrictive/obstructive (1) disease. Pulmonary function results were only available for three of the patients. The remaining two patients were morbidly obese, and the breathing

Table 1

Characteristics of the Sample

Sample: n = 5

Age: 34-79 years (mean = 56.4 years)

Gender: 4 females, 1 male

Mental status: Alert, oriented

Admitting Diagnoses:

1 Hematemesis complicated by respiratory arrest

1 Pneumonitis right lung, mesothelioma right pleural cavity

1 Respiratory failure, Pickwickian syndrome

1 Respiratory failure, chronic obstructive disease, anxiety

1 Respiratory failure, bronchitis, bronchospasm

*FEV1: 0.47-1.05 L (mean = 0.68 L)

*FVC: 1.02-1.64 L (mean = 1.36 L)

*FEV1/FVC: 33-64% (mean = 49%)

*Pulmonary function parameters only available for 3 patients

pathology was assumed to be restrictive. The patient in the sample experiencing the most severe dyspnea had mixed restrictive and obstructive pulmonary pathologies (Table 2).

Table 2

Relationship of Severity of Dyspnea to Pulmonary Disease

Patient	Pulmonary Disease Process	Severity of Dyspnea (VAS) (mean + SD)
A	Restrictive (FEV1 1.05 L, FVC 1.64 L)	18.3 ± 19.6
B	Assumed restrictive	14.9 ± 19.6
C	Obstructive (FEV1 0.47 L, FVC 1.42 L)	8.1 ± 6.7
D	Assumed restrictive	3.2 ± 1.1
E	Obstructive/restrictive (FEV1 1.02 L, FVC 0.52 L)	56.3 ± 30.0

VAS Visual Analogue Scale

Relationship Between Human Field Indices and Severity of Dyspnea

For the total sample, there was a statistically significant, weak positive correlation between the severity of dyspnea and arterial pCO2 ($r = 0.28$) and static pressure ($r = 0.22$), and a weak negative correlation with minute volume ($r = -0.31$) (Table 3). Static pressure readings were not obtained for one patient, since Hospital B did not routinely obtain this information for its ventilator-assisted patients. Correlations between perceived dyspnea and peak inspiratory pressure, arterial pH, and arterial pO2 showed no

statistical significance at the 0.05 level.

Table 3

Relationship Between Severity of Dyspnea and Human Field Indices

Human Field Index	No. Data sets	r	p
pH	66	0.07	<.59
pO2	65	-0.21	<.10
pCO2	67	0.28	<.03
Peak Insp Pressure	162	-0.01	<.91
Static Pressure	114	0.22	<.02
Minute Volume	174	-0.31	<.001

Note: Severity of dyspnea as marked on visual analogue scale

Relationship Between Environmental Field Indices and Severity of Dyspnea

Nurses recorded environmental indices in a total of 166 of the 206 available data sets completed during the study. Analysis of the 166 data sets showed nurses recorded a total of 32 different environmental events or conditions occurring at or within 30 minutes prior to the time of data collection (Table 4). There was a moderate positive, statistically significant correlation ($r = 0.49$, $p < .001$) between the number of indices in the environment recorded by nurses and severity of dyspnea (with VAS). The correlation between dyspnea and the number of environmental indices was similar

with the MBS ($r = 0.51$, $p < .001$).

Table 4

Environmental Factors/Activities Concurrent with Dyspnea

Environment	Activities	Events
Hectic	Prepped for Surgery	Doctor talking
Physician/bedside	IV sites manipulated	Assessment
Family/bedside	X-ray taken	Nurses talking
Change of shift	Change pt. position	Resp. distress
Quiet	Labwork drawn	
Death next bed	Vital signs	
Busy	Sit up in chair	
Hot	Treatment	
Three ventilators	Bedscale weight	
Engineers/bedside	Medications	
	Physical therapy	
	Patient restrained	
	Suctioned	
	Swan Ganz insertion	
	Extubation	
	Bathed	
	Linen change	
	Bedpan/commode	

Nursing and Patient Actions Taken in Response to Dyspnea

The question "What did the nurse or patient do to control the dyspnea?", was included in each data set. The

most frequent actions taken by nurses in an attempt to relieve the patient's dyspnea were suctioning, changing the patient's position, and "bagging" the patient (Table 5). All of the responses were in terms of nursing interventions to treat dyspnea except for "changing position", which was recorded as both a patient and nurse initiated activity.

Table 5

Actions to Control Dyspnea

Action to Control	%	N
Suction	19.7	15
Change patient position	15.8	12
"Bag" the patient	14.5	11
Breathing instruction	13.2	10
Talk with patient	11.8	9
Encourage to relax	9.2	7
Medicate patient	6.6	5
Bronchodilator treatment	4.0	3
Change ventilator setting	2.6	2
Check blood gases	1.3	1
Maintain calm atmosphere	1.3	1
Total number of actions recorded = 76		

Concurrent Validity of VAS and MBS Scales as Measures of Dyspnea

Data demonstrated the ventilator-assisted patient does experience dyspnea, and that the dyspnea may be quantified with the VAS and modified Borg scales. Analysis of the 189

paired data sets of VAS and modified Borg scores showed a strong, positive, statistically significant correlation ($r = 0.92$, $p < .001$). The correlation between the VAS and MBS for each patient is shown in Table 6.

Table 6

Correlation Between Visual Analogue and Modified Borg Scales

Patient	n	r	p
A	12	0.95	<.001
B	21	0.96	<.001
C	59	0.79	<.001
D	59	0.98	<.001
E	38	0.79	<.001
A-E	189	0.92	<.001

n = total number of data sets

Overview of Case Studies

Patient A

The first patient was a 67 year old female admitted with the primary diagnoses of multiple lobe pneumonitis right lung, recurrent pleural effusions, and mesothelioma involving the right pleural cavity. Two years prior to admission, she demonstrated a moderate restrictive pattern with no response to bronchodilators, mild hypoxemia, and severe reduction in vital capacity. Pulmonary function parameters at that time included FEV1 1.05 L (45.8% of value predicted based on individual's height, weight, age, and sex (West)), FVC 1.64 L

(56.3% predicted), and FEV1/FVC 64% (78.5% predicted).

The patient was admitted to the critical care unit for placement of a Swan-Ganz catheter prior to an emergency thoracotomy to determine the etiology of recurrent pleural effusions. The patient had recently seen a television documentary concerning patients being "maintained on ventilators and never being allowed to die". The patient's son obtained Power of Attorney for her, allowing him to require discontinuance of ventilator support should the patient's condition deteriorate. The patient stated numerous times that she was to be a "no code" (no heroic or extraordinary measures to sustain life). The desire to die during surgery was also frequently expressed.

The scores of the VAS and the MBS over a three day period are shown in Table 7 and Figure 1. Ratings between the two scales agreed except in the middle range. There was much greater variation in the VAS than the MBS. When the patient marked the MBS at 3, the VAS ranged between 50 and 60 mm. The first set of dyspnea scores of the graph were obtained prior to the patient's intubation. The patient was receiving oxygen via 31% venti-mask with arterial blood gases pH 7.38, pCO_2 47, and pO_2 48. When marking the MBS 0.5, the patient noted the mask would "make anyone short of breath. I'm claustrophobic." The periods of greatest dyspnea for this patient coincided with the 8 a.m. hour, when the nursing assessment had been completed, the physicians were in the unit, and portable chest x-ray had been taken.

Figure 1

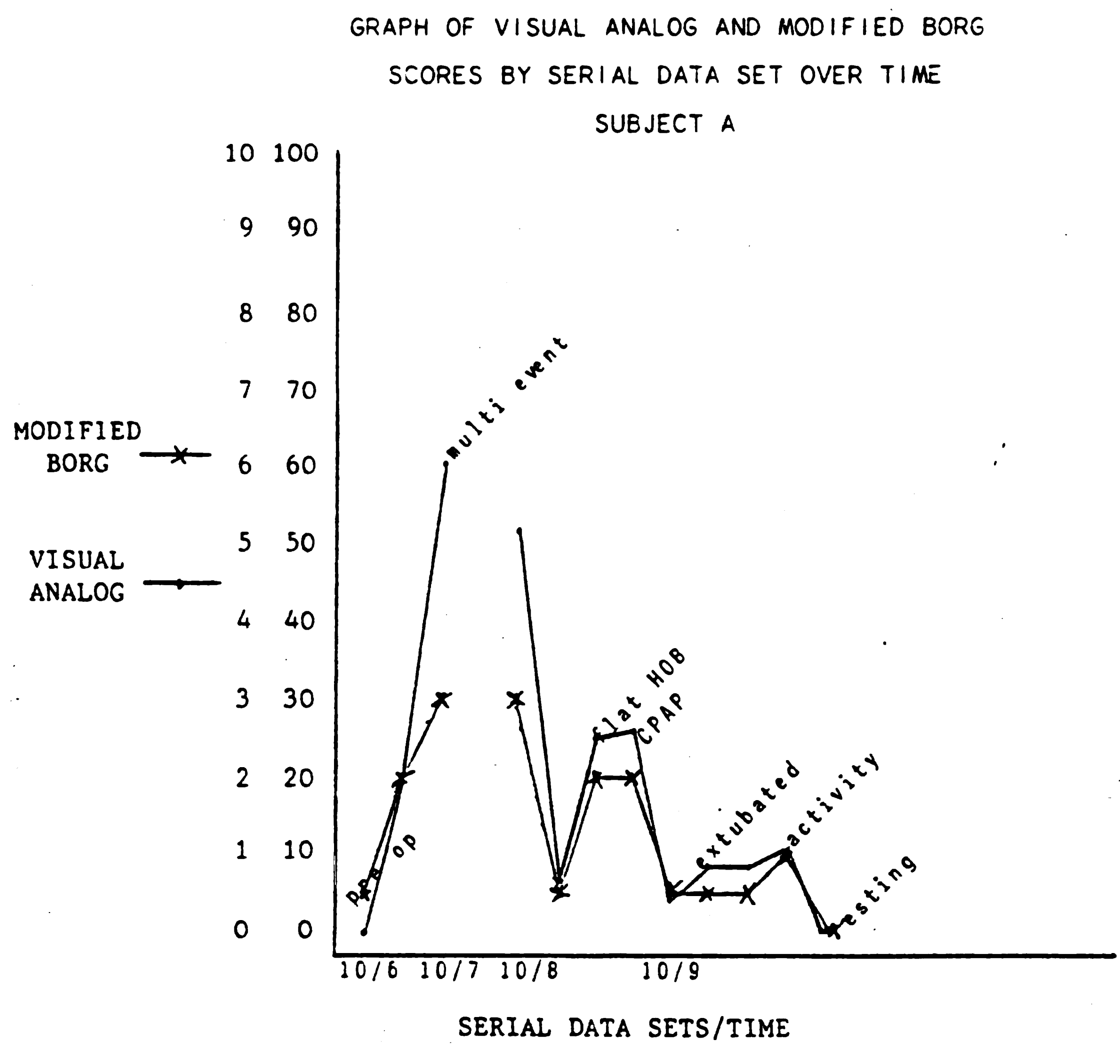

GRAPH OF VISUAL ANALOG AND MODIFIED BORG
SCORES BY SERIAL DATA SET OVER TIME
SUBJECT A
10 100
9 90
8 80
7 70
6 60
5 50
4 40
3 30
2 20
1 10
0 0
MODIFIED BORG
VISUAL ANALOG
multi event
flat HOB
CPAP
extubated
activity
resting
op
10/6 10/7 10/8 10/9
SERIAL DATA SETS/TIME

Table 7

Severity of Dyspnea in Patient A

Measure	N	Mean	SD	Min	Max
MBS	12	1.3	1.1	0	3
VAS	12	18.3	19.6	0	60

When interviewed postextubation, the patient stated it was not the ventilator that made her short of breath. She stated, "The worst time [on the ventilator] was when I was turning and when they got my weight." "The suctioning was O.K., sometimes it helped". She also stated, that sometimes when she marked the scales, what she was feeling was more like restlessness than shortness of breath.

Patient B

The second patient in the study was a 43 year old, 157 Kg female admitted with a primary diagnosis of respiratory failure and secondary diagnoses of cellulitis and Pickwickian syndrome. The patient had been hospitalized twice in the previous year for pneumonia and bilateral lower lobe atelectasis. The patient was treated with antibiotics and bronchodilator therapies. Chronic therapy with Theophylline 300 mgs four times a day was also initiated.

On the day of admission, the patient was seen in the physician's office complaining of shortness of breath, nocturnal cough with putrid and foul smelling sputum. Following an episode of coughing, during which the patient

became extremely cyanotic, a set of arterial blood gases was obtained. On room air, pH was 7.30, pC02 70, and p02 30. Additional complaints included swelling of her left lower limb with severe pain and tenderness, a five pillow orthopnea, and immediate dyspnea with exertion. There were no previous pulmonary function tests available for this patient. From the admitting diagnoses, and the patient's weight, a primary restrictive disorder was assumed.

Figure 2 shows the VAS and MBS scores over time for this patient. The patient's usual level dyspnea was between 0.5 and 1 on the MBS (mean 1.4) and between 5 and 10 on the VAS (mean 14.9). The only time the patient indicated severe dyspnea, the MBS was rated 9 and the VAS 95. Nurses had just completed postural drainage and percussion, and had suctioned the patient for an extremely large amount of thick yellow secretions. A radial arterial line had recently been changed, and a nasogastric tube inserted. The patient was very cyanotic and coughing.

This patient had frequent episodes of coughing and/or laryngospasm, during which she became extremely cyanotic with obvious labored breathing. However, she did not always indicate that she felt dyspneic at these times. In this patient, visual cues of respiratory distress did not correlate with dyspnea ratings by the patient.

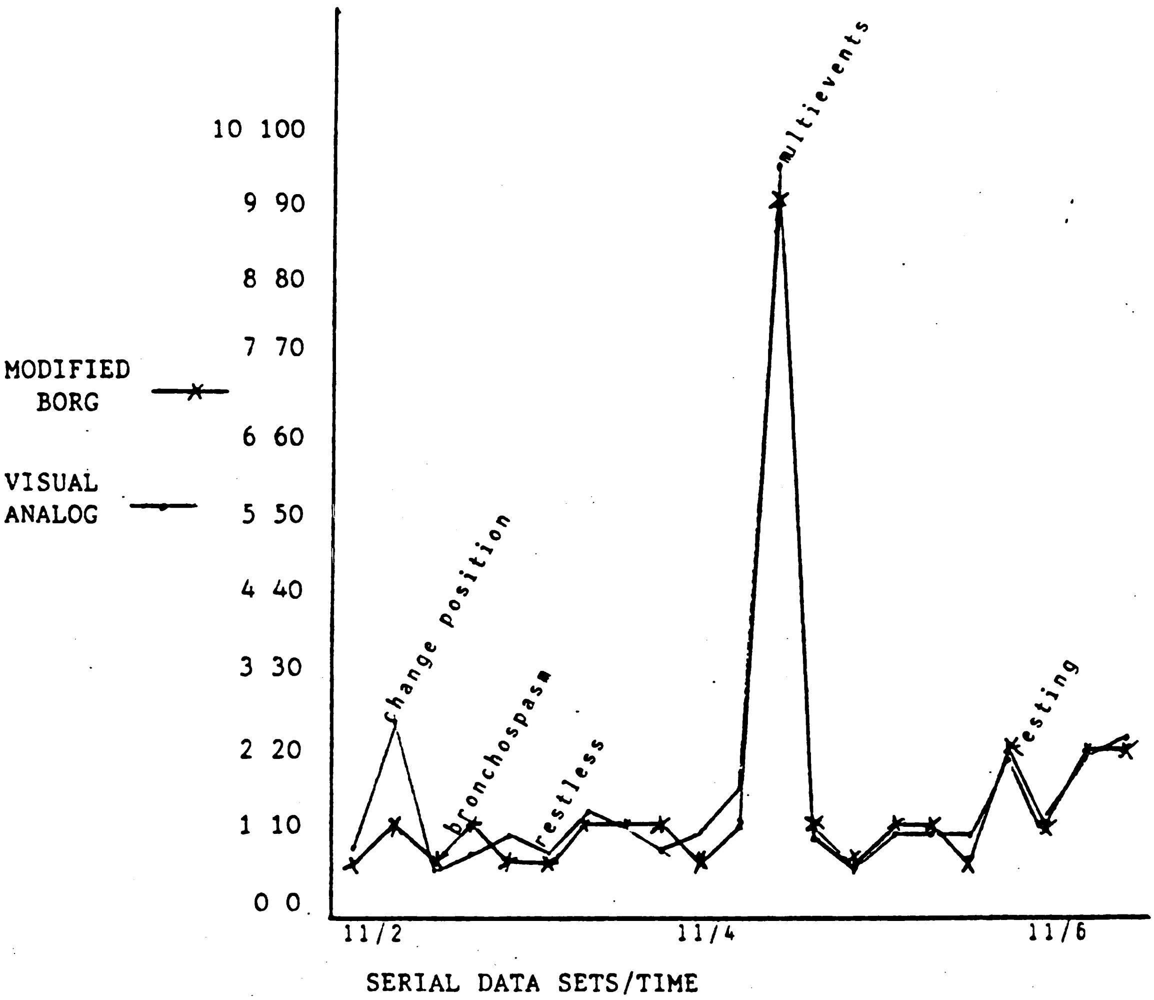
Like the first patient, this patient did not believe that the ventilator itself contributed to her dyspnea. She did state that coughing made her short of breath sometimes.

Figure 2

GRAPH OF VISUAL ANALOG AND MODIFIED BORG

SCORES BY SERIAL DATA SET OVER TIME

SUBJECT B



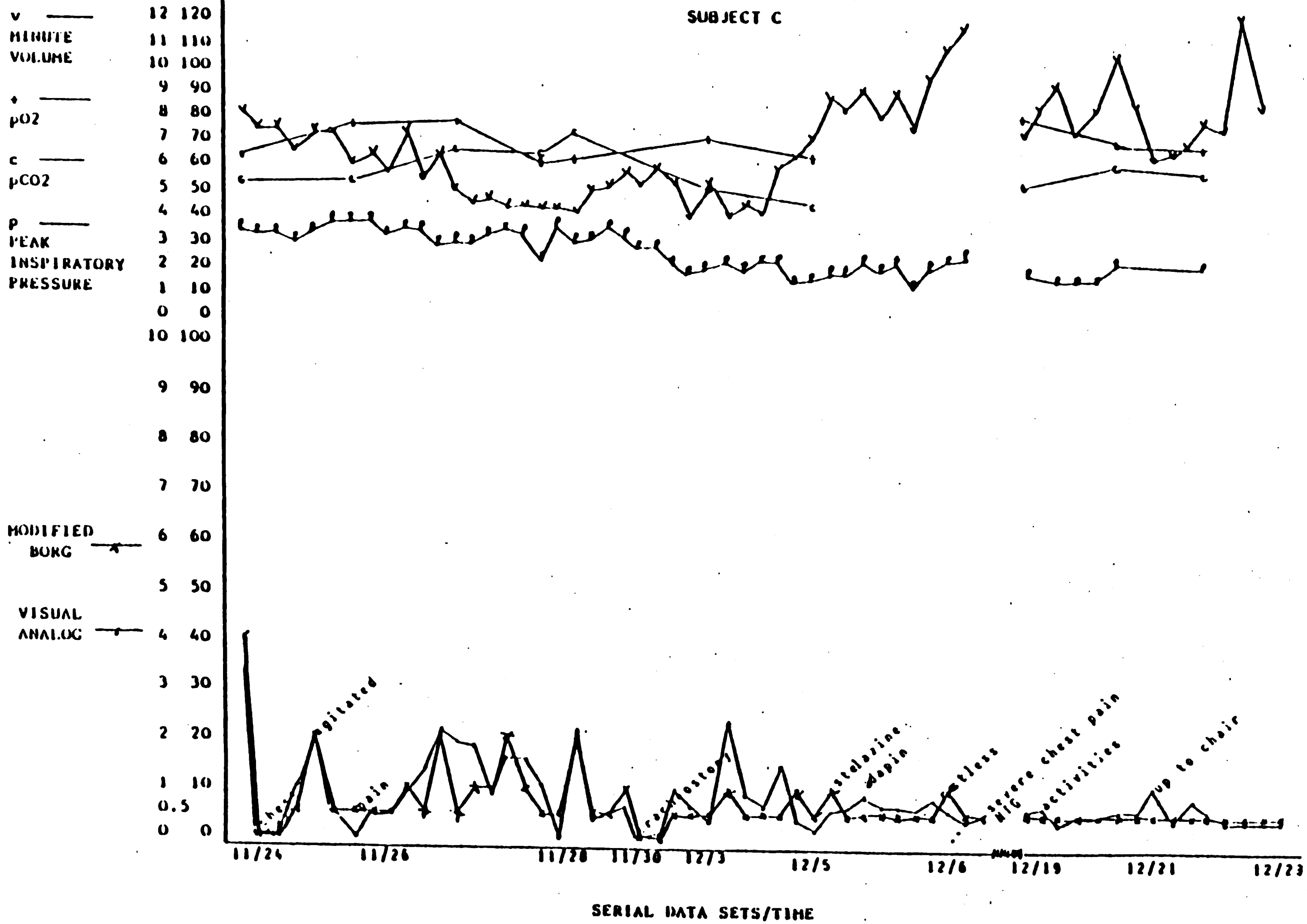
Patient C

The third patient was a 59 year old female admitted with the diagnoses of bronchospasm, acute respiratory failure, severe obstructive disease, and chronic anxiety state controlled with low dose Stelazine and Adapin. Pulmonary history included chronic hypoxemia requiring low flow oxygen therapy. Pulmonary function studies performed three months prior to admission demonstrated a severe decrease in both vital capacity (1.42 L (45.2% predicted)), and FEV1/FVC (33.0% (40.0% predicted)). The test was interpreted by the pulmonary physician as demonstrating a severe obstructive airways pattern with marked air trapping. A treadmill test, performed as part of the pulmonary function screen, lasted a total of 1 minute, 38 seconds into stage one of the pulmonary protocol. The patient became hypoxemic, with the oxygen saturation dropping from 93% to 74%, and developed shortness of breath without chest pain or ischemia. Oxygen saturation recovery time was prolonged to six minutes. Based on the treadmill results, this patient might be expected to experience dyspnea during patient care activities requiring exertion in the critical care unit. Figure 3 shows the relationship between pCO2, pO2, minute volume, peak inspiratory pressure, VAS and MBS over time. The patient's dyspnea varied between 0 and 35 on the VAS (mean 8.1) and 0 and 4 on the MBS (mean 0.7) (Table 8). The patient demonstrated more variation in dyspnea during the first five days of data collection, and little variation during the

Figure 3

GRAPH OF VISUAL ANALOG AND MODIFIED BORG SCORES BY SERIAL DATA SET OVER TIME

SUBJECT C



final six days of data collection.

Table 8

Severity of Dyspnea in Patient C

Measure	N	Mean	SD	Min	Max
MBS	59	0.7	0.6	0	4
VAS	59	8.1	6.7	0	34

Concurrent with the last six days of therapy, the patient's minute volume was higher and the patient's activity increased. There was a weak negative correlation between minute volume and dyspnea across the patient sample. Examples of the patient's increased activity included getting up to the commode, walking at the bedside, and getting up to the chair several times a day. Based on her treadmill results, a greater degree of dyspnea had been expected during this exercise, but this did not occur. The patient was on Stelazine during this period of time, which may have blunted her response to dyspnea. Stelazine and Adapin (antidepressants), two of the patient's routine medications, had been discontinued the night she was intubated, and restarted the night of December 4th.

Patient D

The fourth subject was a 34 year old, 336 Kg male with a primary admitting diagnosis of gastrointestinal bleeding complicated by a respiratory arrest. The patient was intubated and placed on mechanical ventilation. Pulmonary

history was negative through seven years of previous admissions for cellulitis and phlebitis. However, the patient did state to the nurse on this admission that he could not breathe lying flat.

Figure 4 pictures the patient's VAS and MBS scores over time. This patient experienced very little dyspnea (Table 9). During the first marked increase in the patient's perceived dyspnea, there were no observable changes in the patient's condition. In contrast, the second period of severe dyspnea was associated with the transfer of the patient to a new bed, and the third peak immediately followed suctioning, and the turning of the patient in bed. Due to the patient's size, it took 7 to 8 nurses to accomplish turns and transfers. The patient was consistently noted to appear exhausted after this activity.

Table 9

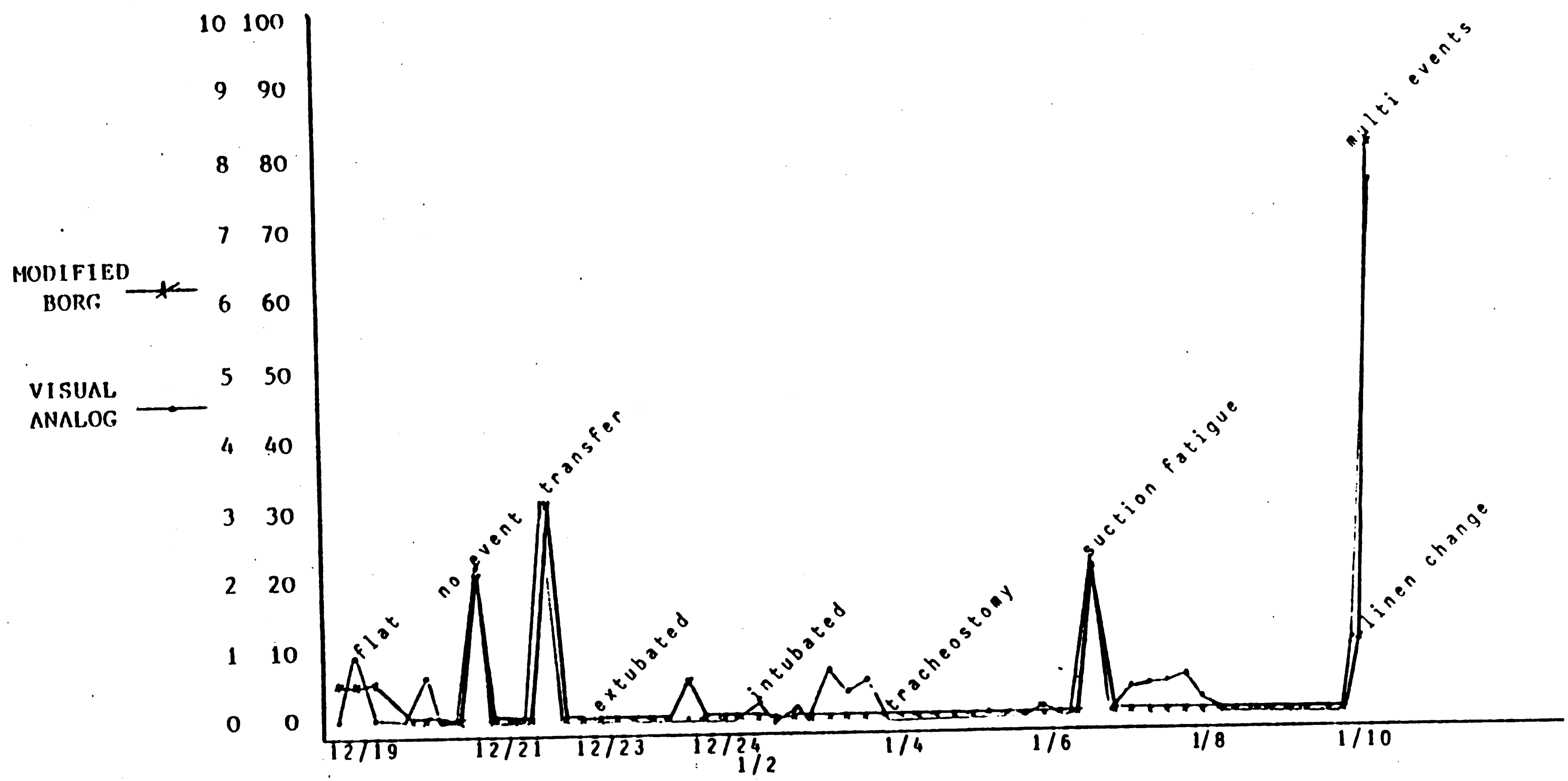
Severity of Dyspnea in Patient D

Measure	N	Mean	SD	Min	Max
VAS	59	3.2	10.8	0	75
MBS	59	0.3	1.1	0	8

The last period of severe dyspnea was marked by a significant change in the patient's condition. The patient had just been turned several times for a linen change, and had been suctioned of 250 cc of dark brown liquid through the tracheotomy. The patient was cyanotic, apprehensive, and

Figure 4

GRAPH OF VISUAL ANALOG AND MODIFIED BORG SCORES
BY SERIAL DATA SET OVER TIME
SUBJECT D



diaphoretic. His temperature was 38.3 degrees centigrade, and the patient had developed atrial fibrillation with a ventricular response of 200 per minute. He was transferred to the county hospital that afternoon and died three days later from massive pulmonary emboli.

Prior to his death, the patient was interviewed during a seven day period in the middle of the study, when he was extubated. He demonstrated "stacatto speech" taking a breath every second or third word while speaking. During these interviews, he rated his dyspnea at zero. This patient also indicated his dyspnea while on the ventilator was not due to the ventilator itself, rather, the patient noted that turning in bed, suctioning, and his physical therapy exercises made him feel short of breath.

Patient E

The fifth patient entered into the study was a 79 year old female weighing 46.4 Kg. She was hospitalized due to sudden onset of wheezing, coughing, and shortness of breath. Primary diagnoses included bilateral bronchospasm with acute bronchitis. Secondary diagnoses included controlled congestive heart failure, chronic obstructive pulmonary disease, fever, osteoporosis, and history of dumping syndrome. Chest x-rays documented hyperinflation, and pectus excavatus with kyphosis.

Pulmonary function parameters were FEV1 1.02 L (42.5% predicted), FVC 0.52 L (28.2% predicted), and FEV1/FVC 51.4% (63.5% predicted). The patient had a mixed restrictive and

obstructive disease. Routine medications included theophylline, isosorbide, prednisone, and a beta adrenergic bronchodilator.

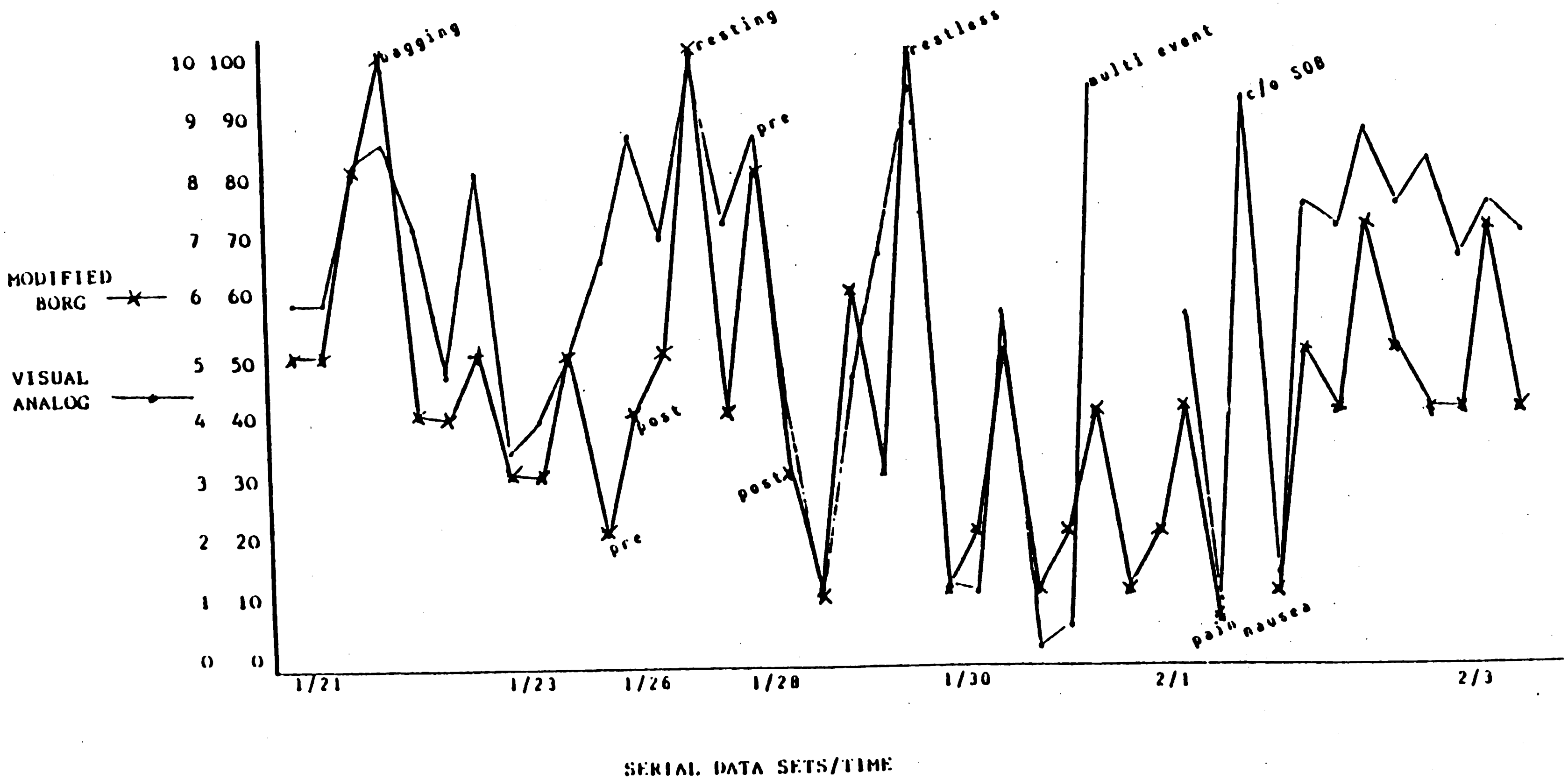
This patient often stated she was always short of breath, and that nothing could relieve her dyspnea. She asked to be "bagged" as often as every ten minutes. Although ventilator-assisted patients frequently asked for bagging to relieve dyspnea, it is unknown why "bagging" has a therapeutic effect in these patients. Possible reasons may include reduction in the work of breathing, or that the tidal volume delivered by the bag functions as a sigh. Sighs, which normally occur 6 to 10 times per hour, play a role in preventing alveoli from collapsing (Shapiro, 1975). The critically ill patient may not be able to effectively sigh due to their pulmonary pathology, muscle weakness, or the settings of the ventilator (control or assist control).

The severity of dyspnea in this patient was labile, varying from maximal to very, very slight (Table 10). Figure 5 illustrates the severity of this patient's dyspnea over time. There were two instances during which the dyspnea scales were administered before and after suctioning. The first time, the patient was suctioned by the respiratory therapist as part of the routine care of the patient, post bronchodilator treatment. The patient's dyspnea scores on the VAS increased from 65 pre-suctioning to 87 after being suctioned. The second episode of suctioning was initiated by patient complaint of difficulty in breathing. The nurse

Figure 5

GRAPH OF VISUAL ANALOG AND MODIFIED BORG SCORES BY SERIAL DATA SET OVER TIME

SUBJECT E



suctioned a large sputum plug from the endotracheal tube. This time, the patient's report of dyspnea decreased from 86 prior to suctioning, to 41 post suctioning.

Table 10

Severity of Dyspnea of Subject E

Measure	N	Mean	SD	Min	Max
MBS	40	4.2	2.6	0	10
VAS	39	56.3	30.0	0	95

Discussion

Dyspnea was experienced by all patients regardless of age, gender, medical diagnosis or pulmonary disease pathology. Each patient entered into the study experienced dyspnea during mechanical ventilation. Four patients had a baseline intensity of dyspnea which ranged from "none at all" to "slight" (MBS), with peaks of increased severity of dyspnea. The fifth patient's mean severity of dyspnea was "somewhat severe" to "severe", with frequent vacillations between low and maximum degrees of dyspnea. Periods of increased dyspnea were usually associated with activities across the patient sample.

Patients with both restrictive and obstructive pulmonary diseases experienced dyspnea while receiving mechanical ventilation. The patient experiencing the most severe mean dyspnea over time was diagnosed with mixed restrictive/obstructive pulmonary disease. The mean severity of dyspnea for this patient was 53.3, whereas the mean severity of dyspnea experienced by patients with either restrictive or obstructive disease ranged from 3.2 to 18.3 on the VAS. However, patients with only one diagnosed pulmonary disease category could presumably have had both processes operating during severe pulmonary distress.

The human field indices measured in this study for their relationship to severity of dyspnea were pH, pO2, pCO2, peak inspiratory pressure (PIP), static pressure (SIP), and exhaled minute volume (VE). These variables were selected

after a thorough review of currently proposed mechanisms of dyspnea.

In this study, pCO_2, PIP, and VE were weakly but significantly related to severity of dyspnea. Static pressure, a measure of lung and chest wall compliance, increased as dyspnea increased ($r = 0.22$, $p < .02$). There was also a positive relationship between pCO_2 and severity of dyspnea ($r = 0.28$, $p < .03$). In contrast, there was a negative relationship between VE and dyspnea ($r = -.31$, $p < .001$). Although these correlations are statistically significant, the clinical significance is unknown. The findings do suggest that these human field indices may be related to dyspnea and should be measured in future clinical studies of dyspnea in ventilator-assisted patients.

It is interesting to note there was no relationship between peak inspiratory pressure and pO_2 and severity of dyspnea in this study. Since the static pressure was related to dyspnea, it was expected that PIP, a measure of total compliance, would also be related. In fact, in this study there was no correlation between PIP and dyspnea ($r = -.01$, $p < .91$). One confounding variable may have been the fact that static pressure measurements were taken from four patients in one hospital, whereas the PIP measurements were from all five patients in both hospitals. An example of the lack of correlation between dyspnea and pO_2 occurred with Patient A. This patient's mean severity of dyspnea was 18.3 ($\pm$ 19.6 S.D.) despite a pO_2 which was never higher than 53 mm Hg.

Instead, her periods of increased dyspnea were associated with increased numbers of activities.

The environmental field indices recorded in this study were: patterns of noise or light; numbers and types of nursing activities; presence of additional personnel and family at the bedside; additional equipment at the bedside; numbers and characteristics of other patients in the unit; and unit activities such as change of shift. In the post extubation interviews, patients uniformly stated that the ventilator itself did not cause their dyspnea. Rather, the patients associated their dyspnea with environmental field indices including nursing activity, physical therapy, suctioning, and coughing. There was some congruence between the patients' perceptions of those activities which precipitated dyspnea and those recorded by nurses during periods of dyspnea. For instance, physical therapy and suctioning were mentioned by both the nurses and patients. There were in fact a total of 32 environmental indices recorded by nurses. They were categorized into environmental conditions, activities, and events. The environmental field indices recorded which reflected the conditions of the intensive care unit ranged from hectic, to hot, to quiet. Recorded activities were representative of the range of day to day activities normally taking place in an intensive care unit. For example, the list of activities included bathing, linen change, sitting up in a chair, weighing, and manipulation of intravenous lines.

In this descriptive study, the significance, duration and effect of individual environmental conditions, events, and activities were not examined. However, the total number of environmental indices was correlated with severity of dyspnea and demonstrated the strongest relationship to dyspnea found in this study ($r = 0.49$, $p < .001$). Future study should examine the relationship between the individual conditions, activities or events and the duration and severity of dyspnea. The most significant variable may be, as in this study, the total number of environmental indices (conditions, activities and events) preceding with dyspnea.

The principle of integrality states that man and the environment are continuous, mutual, reciprocal fields. This study supported this theoretical premise. Additional support was found for the proposed assessment scheme for dyspnea which included the assessment of both objective and subjective measures of human and environmental field indices. The moderate correlation between the number of environmental indices and the severity of dyspnea (human field disturbance) offered preliminary support for this principle.

There were a variety of responses taken by nurses to control dyspnea in the ventilator-assisted patient. Interventions ranged from suctioning, to sedation, to maintaining a calm atmosphere. In fact, in 91% of the incidents of dyspnea, nursing responses to dyspnea were recorded. This would indicate that nurses currently respond to dyspnea in their mechanically ventilated patients.

Nurses in both hospitals seem to have prioritized their interventions for patients experiencing dyspnea. Most often, the airway was cleared and physical comfort established. The next most frequent responses were nurse communication and teaching directed towards promoting psychological comfort and reducing the work of breathing. The least used interventions involved sedating the patient, ordering bronchodilator treatments, changing the ventilator setting, and checking blood gases. One of the more positive findings of the study was that nurses used nursing interventions such as communications and calming techniques prior to sedating the patient.

There was a strong, positive and significant correlation between the VAS and MBS scales ($r = 0.92$, $p < .001$) demonstrating concurrent validity. The strength of the correlation offers support for the use of either the VAS or the MBS scales as valid and reliable measures of dyspnea in the ventilator-assisted patient in the critical care setting.

One of the important findings of this study is that both the VAS and MBS scales can be used to quantify dyspnea in the critical care setting. Scale selection then can be based on patient or researcher preference. The expression of scale preference by the patients in this study was rare, and individual to the patient and incident of dyspnea. One patient had no understanding of the VAS. In fact, despite intensive coaching, instead of indicating the amount of dyspnea with a check mark, this patient wrote Valium or

emphysema on the scale (this patient was not entered into the study). A second patient refused the MBS at one time stating "the words are too difficult to read". This same patient later completed the MBS and refused the VAS stating it was "too difficult to understand". For this patient, the overall correlation between the scores of the VAS and MBS was + 0.79 ($p < .001$).

Frequently, in this study, there appeared to be little correlation between the patient's perception of his/her own dyspnea and the nurse's perception of the patient's dyspnea. There were in fact nurses who expressed frustration when a patient's dyspnea scores did not coincide with the nurse's assessment. This lack of congruence between patients and nurses in this study is not unlike the studies of pain where the health care worker's assessment and patient report do not coincide (Fagerhaugh & Strauss, 1977). The discrepancy between the patient's perception of dyspnea and the nurse's assessment suggests that nurses should assess environmental field indices. Additionally, it is important that clinical nurses and researchers measure the patient's perception of dyspnea rather than relying on the nurse's perceptions or patient's clinical manifestations. In fact, the establishment of the patient's baseline should be part of the admission assessment of the patient. This would allow the nurse to quantify the efficacy of patient care interventions.

This study demonstrated that mechanically ventilated patients experience dyspnea. Correlations were identified

between environmental conditions, activities, and events with the severity of dyspnea. Some of those human field indices gleaned from relevant theory were found to be related to the severity of dyspnea; others were not. Future studies are needed to determine the relationship between individual indices and the severity of dyspnea.

The primary implication for nursing practice drawn from this study is the need for the critical care nurse to develop an awareness of the possible presence of dyspnea in the ventilator-assisted patient. The clinical nurse must recognize the importance of relying on the patient's report of dyspnea as the patient's human and environmental field indices may not correlate with the patient's perception of difficulty in breathing. The planning of nursing care to limit the number of conditions, events, and/or activities occurring simultaneously in the patient's environment, is also indicated. Finally, the incorporation of the VAS or MBS scales into the nursing flow sheet to facilitate the routine evaluation of the patient's perception of dyspnea should be considered.

Implications for future research include the continued exploration of the occurrence of dyspnea in other patient populations who receive mechanical ventilations. Additionally, dyspnea needs to be studied in relation to specific nursing activities. Since the number of environmental events and activities showed a moderate positive correlation with dyspnea in the mechanically

ventilated patient, we need information about the duration and the effect of specific activities so the timing of care can be planned. Specific therapeutic interventions for relieving dyspnea during mechanical ventilation must be tested. The efficacy of these interventions for the relief of dyspnea could be assessed by administering the dyspnea scales before and after specific procedures such as bagging. Finally, specific indices of human and environmental fields need to be examined in controlled studies.

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Appendix A

Modified Borg Scale

Circle the number which best matches your shortness of breath.

0	none at all
0.5	very, very slight (just noticeable)
1	very slight
2	slight
3	moderate
4	somewhat severe
5	severe
6	
7	very severe
8	
9	very, very severe (almost maximal)
10	maximal

Appendix B

Visual Analogue Scale

Mark the line at the place

which best matches your shortness of breath.

____

0	100
No difficulty breathing	Can't breathe

Appendix C

Demographic Data Instrument

Patient code ______________

Age ______ Sex ______

Height ______ Weight ______

Ethnic background ______________

Airways ______________

____

Date into study ______________

Date out of study ______________

Reason for termination ______________

____

Comments ______________

____

____

Physician Code ______________

Primary diagnosis ______________

____

Secondary diagnoses ______________

____

Pulmonary history ______________

____

Cardiac history ______________

____

Pulmonary function tests ______________

____

____

____

Appendix D

Field Indices Instrument

Date_____Time____Does the patient complain of dyspnea?______

Ventilator Data	Patient Data	Lung sounds_________
TV____________________	RATE_____________	____________________
FIO2__________________	TV_______________	____________________
SIMV__________________	MODE O2__________	____________________
PEEP__________________	FIO2_____________	____________________
PIP___________________	ABGs time________	Chest X-ray_________
PIP(hold)_____________	pH_______________	____________________
V_____________________	pCO2_____________	____________________
FLOW__________________	pO2______________	____________________

At the onset of dyspnea what were (if any):

Nursing activities involving patient________________________

Physical activity of patient________________________________

Clinical changes in patient condition_______________________

Recent ventilator changes___________________________________

Recent events____

What did the nurse or patient do to control the dyspnea?____

____

Environmental conditions____________________________________

Comments____

Appendix E

Dyspnea in Ventilator-Assisted Patients

Sample

The convenience sample will be those english speaking patients admitted to the critical care unit, aged eighteen years or older, and receiving ventilator-assisted ventilations. Subjects who are invited into the study will be those who, in the judgement of the researcher, are alert, oriented, able to indicate understanding of the use of the visual analog and modified Borg scales, and able and willing to give informed consent.

Procedure

The researcher will provide a thorough explanation of the nature, purpose, risks, and requirements of the study to participating patients. Potential risks to the patient will be explained including the invasion of privacy, inconvenience for the patient, and the possibility that awareness of the sumptom of dyspnea may augment his distress. Signed informed consent will be obtained from the patients.

The patient's nurse will remind the patient at the beginning of each shift to notify the nurse of the occurrence of dyspnea. At four hour intervals, and at patient complaints of dyspnea, the dyspnea tools will be administered to the patient and study data collected by the patient's nurse. The nurse may collect ventilator data and other significant data while the patient is completing the assessment tools. Other data, such as auscultation of lung sounds, will be obtained after patient completion of the scales. The goal is to complete the dyspnea scales prior to activities which could result in dyspnea (e.g. turning, suctioning).

Exceptions to the above protocol would occur if patient condition required the repositioning of the patient prior to tool administration for either patient comfort of safety, if the patient condition would preclude the administration of the tools, and upon patient request to delete part or all of the dyspnea assessment tools during a particular assessment period.

If the patient is mechanically unable to complete the assessment tools, the nurse may complete the visual analog and modified Borg scales for the patient if the patient is able to clearly indicate where placement of the mark on the scale should be. The mark will be accepted by the nurse if the patient indicates acceptance of the location of the mark.

The researcher will be available to the patients and nurses on a daily basis for consultation. Data collection will continue until patient has been weaned from the ventilator for 24 hours, or to a maximum of ten days. Data collection will also cease upon request by the patient to terminate the study, or if change in patient condition makes completion of the tools impractical.

Requirements of Good Samaritan

Institutional Review Board

Patients must be under the care of Dr. Gillette, Dr. Salfen, Dr. Satia, or Dr. Posthumus. A written physician's order must be obtained before informed consent is obtained. Consent must be obtained from Donna Conner (head nurse) prior to the start of the study validating that the study will not interfere with staffing. The study must not interfere with patient care. The patient must also receive a copy of the Bill of Rights.

Examples of Important Data/Observations to Record

Examples include, but are not limited to the following. 1) The position of the patient at the time dyspnea scales are completed or at time of complaint of dyspnea. 2) Nursing activities involving the patient: bedscale weights, changing intravenous lines, x-rays, positions changes, and percussion. 3) Recent events: family visited, doctor visited, treatment, medication for pain or sedation, insertion of a line, death in the unit. 4) Environmental conditions: code in the unit, noisy or hectic environment, family visiting. 5) What the nurse of patient did to control dyspnea: no intervention indicated, suctioned, changed position, talked to patient, sat at the bedside with patient, medicated patient, gave treatment, check blood gasses. Did the intervention help?

Additional Information

Patient data: <u>Rate</u> should be filled out each assessment time. Patient's <u>Tidal volume</u> when on CPAP and IMV. <u>Mode</u> when off ventilator.

ABG's are noted if available. Do not obtain ABG's specifically for this study.

Comments: e.g. "the patient said it was more like restlessness than shortness of breath", shortness of breth is worse when my head is flat". Please note anything which you think may be of significance to this study. Nursing and patient comments have been invaluable to our understanding of dyspnea in the mechanically ventilated patient.