Effect of Intrapulmonary Percussive Ventilation on Mucus Clearance in Duchenne Muscular Dystrophy Patients: A Preliminary Report

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OBJECTIVE: To determine the effects of intrapulmonary percussive ventilation (IPV) on mucus clearance in tracheostomized Duchenne muscular dystrophy patients. METHODS: We studied 8 patients, 5 of whom had mucus hypersecretion (> 30 mL/d). In a randomized, cross-over study we compared assisted mucus clearance techniques with and without IPV. There were 2 treatment sequences and each patient received 5 consecutive days of each treatment sequence, delivered 3 times a day. One sequence consisted of (1) assisted mucus clearance technique (AMCT, which involves forced expiratory technique and manual assisted cough), (2) endotracheal suctioning, (3) nebulizer administration of 5 mL of 0.9% sodium chloride solution for 5 min, (4) a second AMCT session, (5) endotracheal suctioning, (6) 45 min after the end of the nebulizer treatment a third AMCT session, (7) endotracheal suctioning. The other treatment sequence was the same except that it included IPV during the 5-min nebulizer treatment. The collected secretions were weighed. Vital capacity was measured once, before the treatments. Heart rate, respiratory rate, oxyhemoglobin saturation, end-tidal carbon dioxide, airway resistance, and peak expiratory flow were measured before and at 45 min after the treatments. Mean values were compared using analysis of variance with repeated measures. RESULTS: In patients with hypersecretion the mean ± SD weight of the collected secretions was significantly higher with IPV (6.53 ± 4.77 g vs 4.57 ± 3.50 g, p = 0.01). Heart rate, respiratory rate, oxyhemoglobin saturation, end-tidal carbon dioxide, airway resistance, and peak expiratory flow did not differ statistically between the 2 treatments. CONCLUSIONS: IPV is a safe airway clearance method for tracheostomized Duchenne muscular dystrophy patients, and this preliminary study suggests that IPV increases the effectiveness of assisted mucus clearance techniques. *Key words: intrapulmonary percussive ventilation, mucus, clearance, Duchenne muscular dystrophy, neuromuscular, chest physiotherapy.* [Respir Care 2003;48(10):940–947. © 2003 Daedalus Enterprises]

Introduction

In our rehabilitation hospital to date, 266 patients with restrictive respiratory insufficiency have undergone long-term ventilation: 114 with tracheostomy and 152 using noninvasive methods.[1–3] One of the major problems in the daily life of a neuromuscular patient at an advanced stage of the disease is the extreme difficulty in clearing pulmonary secretions, because of low vital capacity (VC) and low spontaneous peak expiratory flow (PEF).[2,4,5] This problem is the main cause of respiratory failure and death for these patients.[6] Furthermore, even under stable conditions the majority of patients present chronic alveolar hypoventilation, with risk of mucus hypersecretion. This in turn favors the appearance of poorly ventilated pulmonary areas, which even when normally perfused, lead to oxygen desaturation and a secondary increase in local hypersecretion.[4,7]

Provision of oxygen is rarely necessary, because there is no obvious specific alveolar dysfunction. Oxygen therapy should be used with caution, as it may exacerbate further carbon dioxide retention in the patient whose condition is purely restrictive.[2] Furthermore, assisted mucus clearance techniques (AMCT) can be performed daily by physiotherapists. AMCT include forced expiratory technique, as-

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sisted cough by manual thoraco-abdominal compression techniques,[2,8] mechanical insufflation-exsufflation,[4] low-lung-volumes breathing techniques,[9–11] and air stacking to increase the peak cough flow.[5]

The advantages of these methods are well known,[4] as are their limitations, such as their relative inefficacy in atelectasis and frequent inability to clear peripheral secretions.[8,10] In fact, in neuromuscular patients AMCT often empties only the trachea, rather than enhancing the clearance of peripheral secretions.[2]

Intrapulmonary percussive ventilation (IPV) has been used in our hospital since 1988. This modified method of intermittent positive-pressure breathing superimposes high-frequency minibursts of gas (at 50–550 cycles/min) on the patient's own respiration. This creates a global effect of internal percussion of the lungs, which could promote clearance of the peripheral bronchial tree. The percussions (sub-tidal-volume) are delivered continuously through a sliding air-entrainment device (called Phasitron) powered by compressed gas at 20–40 psi. The high-frequency gas pulses expand the lungs, vibrate and enlarge the airways, and deliver gas into distal lung units, beyond accumulated mucus.[11] Nebulized drugs can be delivered via entrainment through the Phasitron.

The quality of IPV as a method of ventilation has already been established to be equal to, and in certain conditions superior to conventional ventilation.[12–14] With cystic fibrosis patients IPV is as effective as chest physical therapy.[15–17] Flutter device,[15] and high-frequency chest wall compression,[18] and it seems to be very useful in the acute situation with pediatric patients. Stucki et al[19] reported successfully managing a cystic fibrosis patient in an acute respiratory situation with IPV and helium-oxygen mixture. Deakins and Chatburn[20] demonstrated that IPV is superior to chest physical therapy for treating acute lobar atelectasis in mechanically ventilated pediatric patients. Birnkrant and Pope[21] found IPV effective with neuromuscular patients suffering persistent pulmonary consolidation not responsive to conventional therapies.

The aim of the present preliminary study was to compare 2 different AMCT-plus-nebulized-saline treatment sequences: one with and one without IPV during nebulization. This study was carried out with neuromuscular patients who were undergoing mechanical ventilation and whose clinical conditions were comparable. In order to be able to specifically weigh only the secretions that had migrated into the trachea from the bronchial tree, we chose only tracheostomized patients, from whom we could collect all the secretions via simple endotracheal suctioning.

Methods

Ventilation Via Intrapulmonary Percussion

IPV was delivered with a percussive ventilator (Percussionator IPV2; Percussionaire, Sandpoint, Idaho). The percussion frequency was set at 120 cycles/min, the inspiratory-expiratory ratio was "inverted" (ie, set at 2/1), and the maximum proximal airway pressure was limited to 40 cm H_2O. The physiotherapists who took part in the study were trained and experienced in IPV.

Population

We chose to study a population of patients with Duchenne muscular dystrophy. At an advanced stage of the illness these patients are characterized by functional tetraplegia, total muscular atrophy, and severe restrictive respiratory insufficiency.

We targeted a homogeneous population, using the following inclusion criteria: all patients had Duchenne muscular dystrophy[22] and required long-term ventilation (at least 18 out of 24 h per day). With all the patients, VC was $<$ 600 mL and PEF was $<$ 150 L/min. All patients had a cuffless tracheostomy tube that permitted suctioning and weighing of secretions. The protocol was approved by our institution's ethics committee, and all patients provided informed consent.

Exclusion criteria included repeated choking episodes, unstable cardiorespiratory status (as indicated by pulse-oximetry-measured oxygen saturation [S_{pO_2}] $<$ 95%), systolic blood pressure $<$ 100 mm Hg, or pyrexia.

Subjects

Eight Duchenne muscular dystrophy patients fulfilled the above criteria. Table 1 shows the patients' characteristics. Five of the 8 subjects had mucus hypersecretion ($>$ 30 mL/d).[23,24]

Treatment Sequences

All patients were required to stay in the hospital for 5 days in order to follow the 15-treatment regimen, which involved alternating treatments of the IPV+ sequence (AMCT plus IPV during aerosol) and the IPV– sequence (AMCT plus aerosol but without IPV). The first treatment was chosen at random. All patients were treated in sitting position. Figure 1 illustrates the treatment sequence, which consisted of 3 successive stages:

T0: AMCT using forced expiratory technique and manual assisted cough to increase PEF, with endotracheal suctioning to clear the trachea of secretions, followed by nebulizer administration of 5 mL of 0.9% sodium chloride solution for 5 min. In the IPV+ sequence IPV was administered during the T0 period of aerosol administration. The IPV– sequence did not include any IPV.

T1: Immediately after the T0 treatment, a second AMCT session was performed.

T2: 45 min after the end of T1, a third AMCT session was performed.

Table 1. Patient Characteristics

Patient Number	Age (y)	MV (h/24 h)	VC (mL)	VC (% pred.)	PEF (L/min)	Hypersecretive (> 30 mL/d)
1	29.4	19	400	18	70	Yes
2	17.1	22	485	22	95	Yes
3	20	18	495	20	125	Yes
4	19.7	20	560	27	70	Yes
5	22.1	23.5	520	23	67	No
6	24.3	23.5	300	12	25	Yes
7	22.3	23.5	330	13	26	No
8	22.6	23.5	320	15	58	No
Mean ± SD	22.2 ± 3.7	21.6	426.3 ± 101.4	18.8	67 ± 33.1	

MV = mechanical ventilation.
VC = vital capacity.
% pred. = percent of predicted value.
PEF = peak expiratory flow.

The IPV+ sequence was the same as the IPV– sequence, except that the IPV+ sequence included IPV during the 5-min aerosol administration.

All 8 subjects were ventilated via tracheostomy, so IPV and the nebulized solution were delivered via the tracheostomy tube.

Suction was carried out with a 3-hole suction catheter with a mucus trap attached. This system was weighed before and after suctioning to obtain the secretion weight. The negative pressure of the extraction pump (816 cm H_2O) was started after the catheter was introduced through the tube and placed just above the carina. The suction was conducted while progressively withdrawing and turning the catheter over the course of 15 seconds. This procedure minimizes the risk of local trauma from the negative pressure. No supplemental oxygen was delivered before, during, or after suctioning.

Each patient underwent 3 treatment sequences per day, at 4-hour intervals, for 5 consecutive days. Since there were 8 patients and each patient underwent 3 daily treatments for 5 days, there were a total of 120 treatments. All variables were analyzed separately for the 5 hypersecretive patients and the 3 nonhypersecretive patients.

Measurements and Controls

The variables measured were heart rate, respiratory rate (f), S_{pO_2}, end-tidal carbon dioxide (P_{ETCO_2}), measured with a combination monitor (OxiCap 4700; Datex Ohmeda, Helsinki, Finland), airway resistance (R_{aw}) measured via oscilloresistometry (Vitalograph LF; Vitalograph, Hamburg, Germany), and PEF and VC measured with a volume monitor (model 5410; Datex Ohmeda, Helsinki, Finland). VC was measured once only, at the beginning of the study. Secretions were weighed with a balance (Mettler PJ Deltarange; Mettler-Toledo, Greifensee, Switzerland). Except for VC all variables were measured at T0, T1, and T2 (see Fig. 1). It is important to note that the weight of collected secretions at times T1 and T2 were combined to

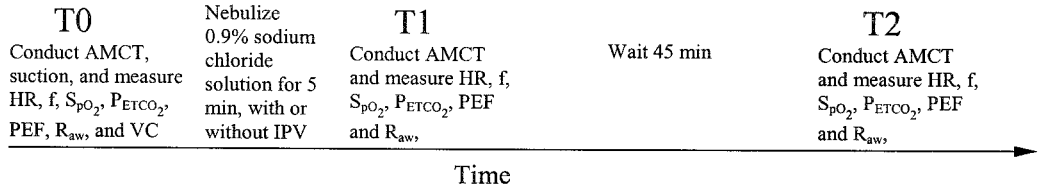

Fig. 1. Experiment timeline. During the period T0 the patient received assisted mucus clearance techniques (AMCT) (including forced expiratory technique and manual assisted cough) and endotracheal suctioning was used to collect secretions. Then we measured 7 physiologic variables: heart rate (HR), respiratory rate (f), oxyhemoglobin saturation measured via pulse oximetry (S_{pO_2}), end-tidal carbon dioxide (P_{ETCO_2}), airway resistance (R_{aw}), peak expiratory flow (PEF), and vital capacity (VC). T0 was immediately followed by nebulizer administration of 5 mL of 0.9% sodium chloride solution for 5 min, with or without intrapulmonary percussive ventilation (IPV). Then, at T1, another AMCT session was performed, secretions were again collected, and HR, f, S_{pO_2}, P_{ETCO_2}, R_{aw}, and PEF were measured. At T2 (45 min after the end of T1) a third AMCT session was performed, secretions were collected again, and HR, f, S_{pO_2}, P_{ETCO_2}, R_{aw}, and PEF were measured again.

Table 2. Weight of Collected Secretions*

Patients	Treatments (*n*)	IPV+		IPV−	
		T0	T1 + T2	T0	T1 + T2
5 Hypersecretive patients	75	3.87 ± 3.33	6.53 ± 4.77†	4.27 ± 3.04	4.57 ± 3.50
3 Nonhypersecretive patients	45	1.73 ± 1.01	1.88 ± 1.23	1.87 ± 2.51	2.39 ± 1.89

*Values are mean ± SD grams.
IPV = intrapulmonary percussive ventilation (See text for descriptions of IPV+ and IPV− treatment sequences.)
T0 = before any treatment.
T1 + T2 = 45 min after T0.
†Statistically significant difference between IPV+ and IPV− (p = 0.01).

evaluate the total of secretions collected in the 45 min following the treatment sequence (IPV+ or IPV–).

Statistical Analysis

This was a randomized clinical study, with the first sequence for each patient chosen by random draw. It was also a cross-over study, with each patient serving as his or her own control. The data were analyzed with statistics software (Statistica; StatSoft, Tulsa, Oklahoma). Differences were calculated with analysis of variance with repeated measures. Differences were considered statistically significant when p was < 0.05. A 2-way analysis of variance was performed to determine the main effect and the interaction effect of treatment (IPV+ and IPV–) and time (T0, T1, T2).

Results

All patients reported no adverse events and tolerated all treatments well.

Weight of Secretions

Among the hypersecretive patients there was a significant difference between IPV+ and IPV–. The mean ± SD weight of collected secretions (T1 plus T2, 45 min after treatment) was 6.53 ± 4.77 g with IPV+, versus 4.57 ± 3.50 g with IPV– (p = 0.01). We were able to compare 75 treatment sequences from the hypersecretive group: 38 IPV+ and 37 IPV– (Table 2 and Fig. 2). Among the nonhypersecretive patients there was no significant difference between IPV+ and IPV–, based on comparison of 45 treatment sequences.

Other Variables

Table 3 shows the heart rate, f, S_{pO_2}, P_{ETCO_2}, R_{aw}, and PEF values from the 5 hypersecretive patients. R_{aw} and PEF did not differ significantly between the treatment sequences. However, PEF improved significantly between T0 and T1 after both treatment sequences: with IPV+ the PEF increased from 55.3 L/min to 60.7 L/min ($p < 0.01$)

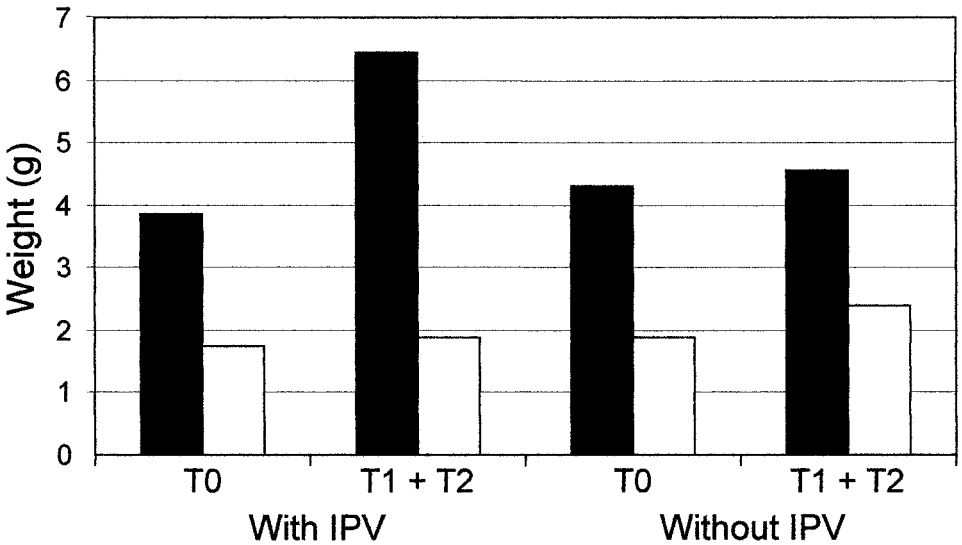

Fig. 2. Mean weight of collected secretions before (T0) and up to 45 min after treatment (T1 + T2) with and without intrapulmonary percussive ventilation (IPV). Black bars represent the hypersecretive patients. White bars represent the nonhypersecretive patients.

Table 3. Other Measurements From the 5 Hypersecretive Patients*

Measurement	IPV+ (n = 38 treatments)			IPV− (n = 37 treatments)		
	T0	T1	T2	T0	T1	T2
HR (beats/min)	107.8 ± 14	101.8 ± 12.1†	104.7 ± 14.2	107.5 ± 12.8	105.6 ± 10.9	103.4 ± 11.8
f (breaths/min)	23.7 ± 8.3	24 ± 9.4	23.5 ± 7.8	24.1 ± 8.7	24.9 ± 9.6	24.9 ± 9.6
S_{pO_2} (%)	97.4 ± 1.8	97 ± 1.5	97 ± 1.4	96.9 ± 1.6	96.7 ± 1.4	96.9 ± 1.6
P_{ETCO_2} (mm Hg)	28.7 ± 7.9	27.7 ± 7.5	28.1 ± 7.9	28.1 ± 8.5	28.5 ± 7.8	28.0 ± 7.7
R_{aw} (mm Hg/s/L)	4.7 ± 1.6	3.9 ± 1.6†	4.0 ± 1.6	4.4 ± 1.8	4.4 ± 1.7	4.1 ± 1.6
PEF (L/min)	55.3 ± 23.4	60.7 ± 22.9†	65.1 ± 22.9	54.9 ± 24.5	59.6 ± 23.8†	59.3 ± 22.4

*Values are mean ± SD.
IPV+ = intrapulmonary percussive ventilation plus assisted mucus clearance technique plus aerosol.
IPV− = assisted mucus clearance technique plus aerosol (no intrapulmonary percussive ventilation).
T0 = before any treatment.
T1 = after treatment with IPV+ or IPV−.
T2 = 45 min after T0.
HR = heart rate.
f = respiratory rate.
S_{pO_2} = arterial oxygen saturation measured via pulse oximetry.
P_{ETCO_2} = end-tidal partial pressure of carbon dioxide.
R_{aw} = airway resistance.
†Statistically significant difference between IPV+ and IPV−.
PEF = peak expiratory flow.

and with IPV– the PEF increased from 54.9 L/min to 59.6 L/min ($p < 0.05$). R_{aw} was significantly different at T1 only with IPV+: it decreased from 4.7 mm Hg/s/L to 3.9 mm Hg/s/L ($p < 0.0001$). Heart rate was significantly lower at T1 after IPV+: it lowered from 108 beats/min to 102 beats/min ($p < 0.001$). This is a small but systematic difference after IPV+, even for the 3 nonhypersecretive patients. No change was observed after IPV–. There was no significant change in f, S_{pO_2}, or P_{ETCO_2} following either treatment. Among the 3 nonhypersecretive patients heart rate, f, S_{pO_2}, P_{ETCO_2}, R_{aw}, and PEF remained stable during both sequences.

The mucus of the hypersecretive group was more colored, more adhesive, and more cohesive than that of the nonhypersecretive group, but these properties were not analyzed further than this general qualitative observation.

Discussion

The aim of this study was to verify the hypothesis that IPV can enhance peripheral bronchial secretion clearance in Duchenne muscular dystrophy patients presenting with hypersecretion. More secretions were collected when AMCT was associated with IPV.

Population

The threshold of efficacy for expectoration is a peak cough flow of about 150–180 L/min,[2,25] so our subjects were unable to clear mucus by spontaneous coughing. Furthermore it was impossible for them to perform low-pulmonary-volume coughing or the usual exercises to control the expiratory flow.[2,8] This population is therefore quite appropriate for the study of airway clearance techniques, because it is physically impossible for these patients to interfere with their treatment. With this type of patient it is logical to think that the data obtained will result from the techniques and their application rather than the level of patient collaboration.

Intrapulmonary Percussive Ventilation Variables

Three variables can be regulated with IPV: frequency, pressure, and inspiratory-expiratory ratio. When the frequency is increased, the volume decreases, as shown by the difference in the area under the pressure curve of each percussion (Fig. 3). On the other hand, increasing the frequency increases the peak pressure, so a higher frequency gives less inspiratory support but creates a more percussive effect, which is more likely to break up mucus cohesion and adhesion and thus mobilize secretions.

When the inspiratory-expiratory ratio is greater (longer inspiration time, such as with the inverted inspiratory-expiratory ratio we used), the pressure peak is smoother, but the volume is more important (see Fig. 3B), so the percussive effect is less and ventilation is increased. The inverted inspiratory-expiratory ratio gives a reverse flow ratio, consisting of a higher flow during expiration than during inspiration, which could help in mucus transport.

When the pressure is increased, both percussive effect and ventilatory support increase. To obtain more percussive effect, the IPV device should be set to a higher frequency and a shorter inspiration time, and the pressure may be increased. In contrast, if more ventilatory support

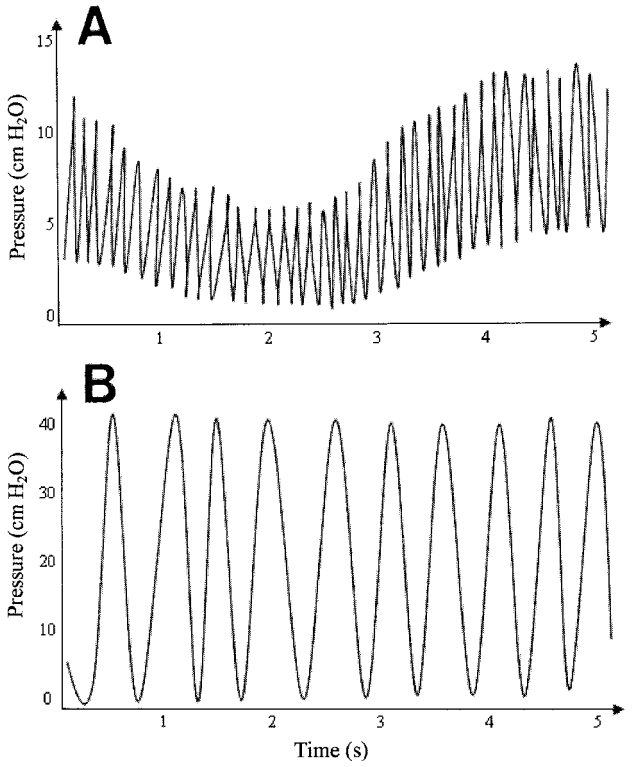

Fig. 3. A: Pressure-versus-time curve from a spontaneously breathing subject receiving intrapulmonary percussive ventilation at 450 percussions/min. The percussions are superimposed on the subject's normal ventilation. B: Pressure-versus-time curve from a patient with no spontaneous ventilatory effort who is receiving intrapulmonary percussive ventilation at 120 percussions/min.

is needed, the frequency should be reduced and the inspiratory-expiratory ratio increased. With a patient whose condition is purely neurologically restrictive, the pressure can reach high intrapulmonary values without risk of barotrauma. In this case the only limitation on the pressure is the patient's comfort. The Phasitron is designed with an open circuit to minimize the risk of barotrauma, and the risk of barotrauma is only anecdotal. However, with patients suffering chronic obstructive pulmonary disease, one should be careful to avoid high pressure; instead use a low pressure and a high-frequency (see Fig. 3A).

In order to correctly adjust the IPV variables, the patient's pathology must be taken into account. In a patient who has ventilatory autonomy but a predominant obstructive component, the intrapulmonary percussions are superimposed on the patient's spontaneous ventilation (see Fig. 3A) as a dynamic continuous positive airway pressure. The lungs are in partial inspiration while internally percussed. The respiratory work is performed by the patient; the percussions do not ensure this function. It is for this reason that the regulation of the percussion frequency and the working pressure target the vibratory effect. The frequency is high, at more than 200 percussions/min, whereas the pressure is low, usually $<$ 20 cm H_2O.[15–18] On the other hand, severely restricted patients who are mechanically ventilated usually have no ventilatory autonomy. In these cases (which our subjects represented) IPV has 2 objectives: (1) percussion to promote mucus clearance and (2) ventilation. With these patients the percussion frequency is lower (80–120 percussions/min) in order to increase the time allowed for the lungs to fill. The maximum proximal airway pressure is 40 cm H_2O, to introduce the highest possible tidal volume (see Fig. 3B).

High-Frequency Techniques

High-frequency oral airway and chest wall oscillation techniques have been studied as a means to enhance clearance of excessive bronchial and peripheral secretions.[26–30] Study results to date appear to be controversial.[10] The differences in the research findings may be explained by the use of different devices and settings, differences in viscoelastic properties of the mucus, and differences in compliance of the models studied.[29] The various mechanisms that could be involved when effectiveness has been demonstrated remain unclear but might include stimulation of the coughing reflex, interaction with ciliary beating, and enhancing mucus-air flow interaction.[30] In our study those first 2 hypotheses can be excluded because our patients were physically unable to cough and because the percussion frequency was around 100 percussions/min, compared to 780–900 cilia beats/min.

We hypothesize that IPV might enhance the mucus-flow interaction. It has been demonstrated that any gas stream flowing over a liquid layer (eg, sputum) creates a shearing force that may move fluid,[30] and the mucus moves in the direction of the higher peak flow velocity.[28] The flow velocity depends on the flow pattern and the dynamic elastic behavior of the airways. According to experiments optimal cephalad mucus transport by air-liquid interaction requires air flow with an expiratory bias.[28] This means a "nonsymmetrical" signal with a shortened expiratory duration, such that expiratory flow is greater than peak inspiratory flow. In our study the inverted inspiratory-expiratory ratio (2:1) of each percussion created expiratory bias, and the bias was amplified by our subjects' normal-compliance airways in a very-low-compliance thorax. In other words, in our patients the elastic recoil of the expiratory system (driving force of the expiratory phase) was very high, decreasing the expiratory time.

Weight of Secretions

The choice of tracheostomized functionally tetraplegic subjects made it possible for us to empty the trachea of secretions and thus to make valid measurements of the weight of the tracheal secretions. By comparing IPV (treat-

ment sequence IPV+) with a classical clearance treatment (treatment sequence IPV–), we hoped to see if the amount of bronchial mucus collected was different 45 min after treatment.

With many subjects it is necessary to analyze both wet and dry sputum weights because lower airway secretions become contaminated with saliva,[26] but with our subjects the secretions came directly from the trachea and were not mixed with saliva or nasal secretions, so it was unnecessary to measure the dry weight. A substantial amount of mucus was collected during the 45 min (T1 + T2) after treatment. After treatment sequence IPV–, an average of 4.57 g was suctioned during T1 and T2, in addition to the 4.27 g already suctioned at T0 (a difference of 7%). This represents the effect of the spontaneous mucociliary clearance work combined with mechanical ventilation between T1 and T2, as well as assisted cough at T1 and T2. The effect of the nebulized solution, which serves to liquefy and thus mobilize secretions, should also be taken into account.

With IPV+, 69% more secretions were collected at T1 plus T2 than at T0 (3.87 g vs 6.53 g, $p = 0.002$). This difference was even more marked in hypersecretive patients; the 2 patients who had the most secretions also had the most marked secretion-weight difference. This suggests that in hypersecretive patients who have a weak cough and very-low-volume spontaneous respiration, IPV mobilizes humidified secretions and increases clearance from the distal airways to the trachea.

We believe that the production of secretions is not induced by the technique itself, because for the nonhypersecretive patients the weight of the collected secretions remained low and there was no difference between IPV+ and IPV– with those patients (see Table 2 and Fig. 2).

Airway Resistance and Peak Expiratory Flow

Table 3 shows the data for R_{aw} and PEF. Although there is no statistically significant superiority of IPV+ over IPV–, PEF was improved with both sequences at T1. It seems logical to suppose that the more open the airways, the higher the PEF. R_{aw} was only decreased after IPV+. This might be correlated to the fact that the greatest amount of secretions was collected after IPV+.

Other Variables

With IPV+ the mean heart rate was significantly decreased at T1 ($p < 0.001$) with both hypersecretive and nonhypersecretive patients. The clinical importance of that difference is unclear without simultaneous exploration of cardiac function (eg, left ventricular ejection fraction).

There was no significant variation in f, S_{pO_2}, or P_{ETCO_2}, which indicates that the patients were stable for the duration of the study and that there was no obvious interaction between the 2 sequences. Even though the treatment sequences were separated by only 4 hours, the patients' starting values at T0 were the same from one treatment to the next.

Clinical Advantages of Intrapulmonary Percussive Ventilation

It has been demonstrated that IPV is a good alternative to other chest physiotherapy techniques[11,15,16] and the present study suggests that IPV is even superior to other techniques with patients suffering severe restrictive pulmonary disease. Moreover, during IPV with those patients the work of breathing is completely performed by the device and the patient is able to tolerate a treatment of ≥ 30 min without fatigue or discomfort. For those reasons IPV is one of the first-choice techniques for mucus clearance in tracheotomized Duchenne muscular dystrophy patients.

Seventy Duchenne muscular dystrophy patients from our center are using IPV as a long-term treatment at home to prevent atelectasis, lower respiratory tract infection, and mucus plugging, and to manage hypersecretion periods.[3] Our 10 years of experience suggests that IPV seems to minimize those problems. Furthermore, with tracheotomized Duchenne muscular dystrophy patients, a daily IPV treatment seems to allow a decrease in the amount of suctioning required during the day and prevents retention of secretions around the tracheostomy tube.

Conclusions

This preliminary report suggests that IPV is a safe mode of treatment for tracheotomized Duchenne muscular dystrophy patients. Furthermore, IPV seems to improve the efficacy of an aerosol therapy combined with ACMT, by enhancing mucus transport from the peripheral respiratory tract. Further studies are required to verify the reported usefulness of IPV in the long-term care of neuromuscularly compromised tracheotomized patients.[3]

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