Evaluation of an Alternative Chest Physiotherapy Method in Infants With Respiratory Syncytial Virus Bronchiolitis

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BACKGROUND: We proposed a new chest physiotherapy (CPT) secretion clearance method to treat respiratory syncytial virus bronchiolitis in infants. Our new CPT method consists of 15 prolonged slow expirations, then 5 provoked cough maneuvers. METHODS: We randomized 20 infants (mean age 4.2 months) into 2 groups: 8 patients received 27 sessions of nebulization of hypertonic saline; 12 patients received 31 sessions of nebulization of hypertonic saline followed by our new CPT method. We used the Wang clinical severity scoring system (which assesses wheezing, respiratory rate, retractions, and general condition) and measured S_{pO_2} and heart rate before each CPT session (T0), immediately after the 30-min session (T30), and 120 min after the session (T150). RESULTS: Within the groups: in the first group, Wang score was significantly lower at T150 than at T0: 4.6 vs 5.0 ($P = .008$). In the new-method-CPT group, Wang score was significantly lower at T30 (3.6 vs 4.3, $P = .001$) and at T150 (3.7 vs 4.3, $P = .002$). Wheezing score was significantly lower at T150 than at T0 (1.1 vs 1.2, $P = .02$) in the first group, and in the new-method-CPT group at T30 than at T0 (0.8 vs 1.3, $P = .001$) and at T150 than at T0 (0.9 vs 1.3, $P = .001$). Between the groups: at T30 the improvement was significantly better in the new-method-CPT group for overall Wang score ($P = .02$), retractions ($P = .05$), respiratory rate ($P = .001$), and heart rate ($P < .001$). At T150 the Wang score was not significantly different between the groups. At T30 (versus T0) the difference in percent gain between the groups was significant for Wang score ($P = .004$), wheezing ($P = .001$), and heart rate ($P = .02$). Over 5-hospital days, the daily baseline (T0) Wang score decreased significantly in the new-method-CPT group ($P = .002$), whereas it did not in the first group. There were no adverse events. Average hospital stay was not significantly different between the groups. CONCLUSIONS: Our new CPT method showed short-term benefits to some respiratory symptoms of bronchial obstruction in infants with acute respiratory syncytial virus bronchiolitis. *Key words: bronchial obstruction; chest physiotherapy; infant; prolonged slow expiration technique; viral bronchiolitis; respiratory syncytial virus; airway clearance.* [Respir Care 2011;56(7):989–994. © 2011 Daedalus Enterprises]

Introduction

Infant viral bronchiolitis is an obstructive lower respiratory tract infection that is responsible for substantial morbidity in children under age 2. Bronchiolitis is characterized by acute inflammation, edema, increased mucus production, and bronchospasm, which affect the flow and the permeability of the small airways, causing hyperinfla-

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Table 1. Wang Clinical Severity Scoring System

	Score			
	0	1	2	3
Respiratory rate (breaths/min)	< 30	31–45	46–60	> 60
Wheezing	None	Terminal expiratory or only with stethoscope	Entire expiration or audible during expiration without stethoscope	Inspiration and expiration without stethoscope
Retractions	None	Intercostal only	Tracheosternal	Severe with nasal flaring
General condition	Normal	—	—	Irritable, lethargic, poor feeding

tion, atelectasis, and wheezing. Bronchiolitis affects more than 10% of children.[1] Most treatments for bronchiolitis have limited efficacy. According to the current literature, conventional chest physiotherapy (CPT) has no effect on outcome, especially on illness duration or hospital stay,[2-4] but new techniques have given encouraging clinical results. In Belgium a 2-stage new CPT method, which was proposed by our group, is widely applied, and was recommended by a consensus conference held in Paris in 2000.[5] The first stage involves a prolonged slow expiration (in French, *expiration lente prolongée*) technique. The second stage involves provoked cough.[6,7] This new CPT method had not been submitted to a controlled trial.

The Wang clinical severity scoring system assigns a value between 0 and 3 to each of 4 variables: respiratory rate, wheezing, retractions, and general condition (Table 1). The maximum Wang score is 12, and a higher Wang score indicates worse condition. Mandelberg and colleagues found a significant change in Wang score in infants with acute viral bronchiolitis by substituting the usual 0.9% isotonic saline solution with a 3% hypertonic saline solution, and a bronchodilator (terbutaline).[8-10] A more recent study showed similar results as to efficacy, safety, and hospital stay in patients with viral bronchiolitis.[11]

During the winters of 2004–2005, 2005–2006, and 2006–2007 we assessed the efficacy of the new CPT method (prolonged slow expiration and provoked cough) following albuterol administered with 3% NaCl hypertonic saline solution on the Wang score of hospitalized infants with respiratory syncytial virus (RSV) bronchiolitis.

Methods

This randomized controlled trial was approved by our institution's ethics committee, all the patients' parents or legal representative gave informed consent, and all research procedures were per the Helsinki declaration.

Subjects

Sixty-five infants with bronchiolitis were admitted to the pediatric unit of the Grand Hôpital de Charleroi, Belgium, during the winter months (November to March) of 2004–2005, 2005–2006, and 2006–2007. Twenty patients met the inclusion criteria:

- First clinical episode of acute bronchiolitis
- Age < 12 months
- Wang score ≥ 3
- RSV in nasopharyngeal secretions, via immunochromatography (Veda Lab, Alençon, France)

The exclusion criteria were:

- Parents' refusal
- No nasopharyngeal RSV
- Comorbidity such as cardiac or neurological disease
- Previous episodes of wheezing
- Wang score < 3
- Prescription of CPT on parents' request
- Chronic lung disease, such as bronchodysplasia
- Immunodeficiency
- Congenital anomaly
- Need for mechanical ventilatory support in the intensive care unit

Randomization and Groups

The enrolled patients were randomly assigned to nebulization of hypertonic saline (the control group), followed in the second group by the new CPT method, based on a stratified sampling for homogeneity (Fig. 1).[12] During randomization, to ensure a balance of illness severity and age across the groups, we grouped the patients into 4 subgroups: Wang score between 3 and 5; Wang score ≥ 6; age < 2 months; and age 2–12 months.

Interventions

Both groups received albuterol in 3 mL of hypertonic saline (3% NaCl), nebulized over 8–10 min with a Side-

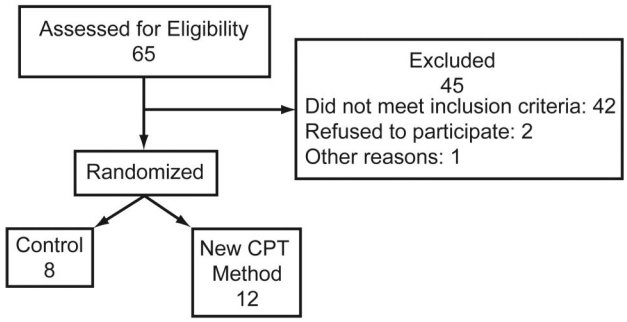

Fig. 1. Flow chart.

stream nebulizer (Respironics, Murrysville, Pennsylvania) at a flow of 8 L/min. The new-method-CPT group then received the new CPT method for 10–15 min.

The new CPT method includes prolonged slow expiration and provoked cough. The prolonged slow expiration slowly increases the intrathoracic pressure through an thoraco-abdominal compression by the clinician, to avoid the bronchial collapse and the flow interruption of forced expirations.[13] Provoked cough is obtained with a brief pressure applied on the trachea above the sternal notch. The cough-induced secretions are swallowed, which obviates nasopharyngeal suctioning and thus avoids the risk of damaging the mucosal lining and/or strong coughing bouts. Most RSV bronchiolitis patients have a high respiratory rate, so for optimal secretion clearance the thoracic pressure is applied during 2 or 3 consecutive expiratory phases. The infant is supine, with a head elevation of 35°, to prevent gastroesophageal reflux.[14] The treatment was applied at least 2 hours after the last meal to avoid reflux vomiting during expectoration. The treatment was carried out once a day until the Wang score was normalized or until hospital discharge, based on the usual criteria: normal food intake and no need for supplemental oxygen.

Data Collection

Two pediatricians evaluated the Wang score variables, S_{pO_2} (N-595, Nellcor/Covidien, Boulder, Colorado), and heart rate. A recent multi-center study that evaluated a clinical scoring system that included the same variables as the Wang score (wheezing, respiratory rate, and retractions) found a high level of inter-observer agreement between physicians, nurses, and respiratory therapists.[15] Both of our pediatrician evaluators were blinded to the applied treatment and goals. The evaluations took place at the beginning of each session (T0), immediately after the 30-min treatment session (T30), and 2 hours after the treatment session (T150). During the study, 3 trained physiotherapists were in charge of administering the treatments, and they were instructed to ignore the results of each evaluation until the end of the study. The patients' parents were unaware of the group in which their child was included. In both groups the periods of time spent in the room were identical, so outside observers were blinded to the applied treatment.

Table 2. Subjects

	Control (n = 8)	New CPT Method (n =12)	P
Age (months)	4.2 ± 3.1	3.9 ± 2.4	.80
Female/male, no.	4/4	2/10	NA
Baseline Wang clinical severity score	6.0 ± 3.2	5.5 ± 2.9	.72
Sessions, no.	27	31	NA
Stay (d)	6.3 ± 2.0	5.3 ± 1.8	.25
Sessions per patient (no.)	3.3	2.5	.41

± values are mean ± SD.
CPT = chest physiotherapy
NA = not applicable

Data Analysis

We entered the data into a spreadsheet (Excel, Microsoft, Redmond, Washington), then imported them into statistics software (Minitab 13.20, Minitab, State College, Pennsylvania). We used the Student t test for paired values to assess the Wang-score changes within the groups, one-way analysis of variance to assess the Wang-score differences between the groups, one-way analysis of variance for independent samples to assess the Wang-score and Wang-score component changes expressed as the differences between the groups, one-way analysis of variance for repeated measures to compare the daily evolution of the Wang score in each group, and the Mann-Whitney U test to compare hospital stay between the groups. We report mean ± SD values. Differences were considered significant when $P < .05$. We did not adjust for multiple comparisons, which is a limitation of the study.

Results

Twenty infants were included and randomized (Table 2). The 8 infants in the control group underwent 27 nebulization sessions. The 12 infants in the new-method-CPT group underwent 31 nebulization and new-method-CPT sessions.

At T0 the baseline Wang scores were not significantly different between the groups. Within the groups (Table 3), in the control group, the session benefit versus T0 was

Table 3. Wang Clinical Severity Score Differences Within the Groups*

	Control			New CPT Method		
	T0 (no. = 27)	T30 (no. = 27)	T150 (no. = 26)	T0 (no. = 31)	T30 (no. = 31)	T150 (no. = 29)
Wang clinical severity score	5.0 ± 2.7	5.1 ± 2.6	4.6 ± 2.9	4.3 ± 2.7	3.6 ± 2.3	3.7 ± 2.7
P		.53	.008		.001	.002
Wheezing	1.2 ± 0.9	1.1 ± 0.8	1.1 ± 0.9	1.3 ± 0.9	0.8 ± 0.8	0.9 ± 0.8
P		.66	.02		.001	.001
Respiratory rate	1.8 ± 0.7	2.0 ± 0.7	1.7 ± 0.7	1.4 ± 0.8	1.3 ± 0.9	1.3 ± 0.8
P		.14	.33		.21	.26
Retractions	1.3 ± 0.8	1.2 ± 0.8	1.2 ± 0.8	1.1 ± 0.7	0.8 ± 0.6	1.0 ± 0.7
P		.71	.16		.03	.21
General condition	0.7 ± 1.3	0.7 ± 1.3	0.7 ± 1.3	0.6 ± 1.2	0.6 ± 1.2	0.5 ± 1.2
P		NA	NA		NA	NA
S_{pO_2} (%)	96 ± 3	95 ± 3	96 ± 2	95 ± 3	95 ± 3	96 ± 2
P		.59	.89		.47	.32
Heart rate (beats/min)	146 ± 18	150 ± 16	144 ± 16	138 ± 15	135 ± 14	139 ± 17
P		.37	.77		.39	.60

* no. = number of sessions
CPT = chest physiotherapy
NA = not applicable

Table 4. Wang Clinical Severity Score Differences Between the Groups*

	T0			T30			T150		
	Control (no. = 27)	New CPT Method (no. = 31)	*P*	Control (no. = 27)	New CPT Method (no. = 31)	*P*	Control (no. = 26)	New CPT Method (no. = 29)	*P*
Wang clinical severity score	5.0	4.3	.37	5.1	3.6	.02	4.6	3.7	.21
Wheezing	1.2	1.3	.87	1.2	0.8	.10	1.1	0.9	.43
Respiratory rate	1.8	1.4	.05	2.0	1.3	.001	1.7	1.3	.06
Retractions	1.3	1.1	.33	1.2	0.8	.05	1.2	1.0	.35
General condition	0.7	0.6	.79	0.7	0.6	.79	0.7	0.5	.60
S_{pO_2} (%)	96	95	.61	95	95	.61	96	96	.83
Heart rate (beats/min)	146	137	.52	150	135	< .001	144	139	.34

* no. = number of sessions
CPT = chest physiotherapy

significant at T150 for Wang score ($P = .008$) and wheezing ($P = .02$), and in the new-method-CPT group the session benefit was significant at T30 ($P = .001$) and at T150 ($P = .001$) for Wang score, and at T30 ($P = .001$) and at T150 ($P = .001$) for wheezing. At T150 the clinical scores were no longer significantly different between the groups.

Between the groups (Table 4), at T0 there were no differences, but at T30 the difference was significantly better in the new-method-CPT group for Wang score, respiratory rate, retractions, and heart rate. At T150 there were no significant differences between the groups.

At T30, versus T0, the percentage gains (Table 5) in both groups were significant for Wang score, wheezing, and heart rate. In the control group, 3 of the 8 infants improved, whereas in the new-method-CPT group 10 of the 12 infants improved.

On day 1 (Fig. 2) the baseline Wang scores were not significantly different between the 2 groups ($P = .72$). In the control group, day by day, throughout the study, the daily baseline Wang score did not change significantly ($P = .06$), whereas it significantly decreased in the new-method-CPT group ($P = .002$) (Table 6). After 5 days, 6 of the 8 control group patients had been discharged, whereas

Table 5. Session Results on Wang Clinical Severity Score*

	Percent Change T0 to T30			Percent Change T0 to T150		
	Control	New CPT Method	*P*	Control	New CPT Method	*P*
Wang clinical severity score	13.3	–22.5	.004	–8.6	–3.2	.47
Wheezing	1.1	–60.7	.001	–12.2	–20.8	.62
Respiratory rate	31.5	0	.11	3.9	11.5	.60
Retraction	3.3	–16.7	.18	–16.7	11.7	.19
General condition	NA	NA	NA	NA	NA	NA
S_{pO_2} (%)	–0.7	–0.66	.98	–0.13	1.2	.36
Heart rate (beats/min)	5.2	–4.7	.02	2.5	–1.66	.34

* Positive values indicate worsening of clinical condition. Negative values indicate improvement of clinical condition.
CPT = chest physiotherapy
NA = not applicable

Table 6. Evolution of Daily Baseline (T0) Wang Clinical Severity Score

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	*P*
Control group	6.0 ± 3.2	6.2 ± 2.8	4.2 ± 1.5	4 ± 3.5	4.3 ± 2.0	3.5 ± 0.7	2	.06
New CPT method	5.5 ± 2.9	4.6 ± 2.7	3.3 ± 2.0	3 ± 1.0	1	NA	NA	.002

CPT = chest physiotherapy
NA = not applicable

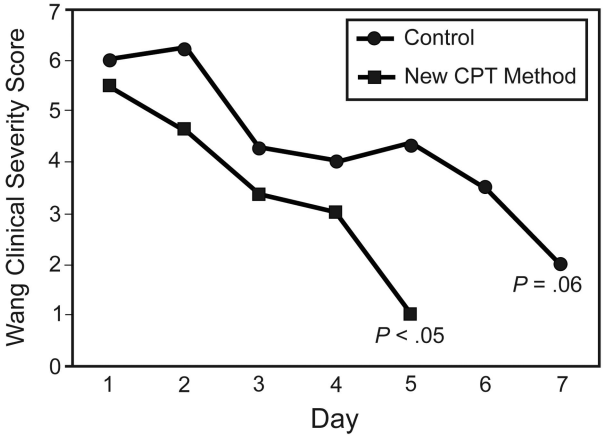

Fig. 2. Daily baseline (T0) Wang clinical severity scores. On day 1 the baseline Wang scores were not significantly different between the groups ($P = .72$).

all 12 of the new-method-CPT group had been discharged. The average hospital stay was not significantly different between the groups: 6.3 ± 2.0 days in the control group, vs 5.3 ± 1.8 days in the new-method-CPT group ($P = .25$). There were no adverse events.

Discussion

This randomized controlled trial showed short-term benefit from our new CPT method on several respiratory variables in infants with RSV bronchiolitis. Thus far, 3 randomized controlled trials have reported conventional CPT in hospitalized patients with bronchiolitis, and those studies found no clinical benefit from vibration and percussion techniques.[2-4] They have in common the association of clapping performed with the cupped hand for 3 min in 5 positions of drainage, assisted cough, and/or oropharyngeal suctioning. These maneuvers may be detrimental to infants, and the American Academy of Pediatrics and a Cochrane systematic review do not recommend conventional CPT.[16,17] Our new CPT method is more attuned to pulmonary physiology, and in our study there were no adverse events. The main component of our new CPT method is the prolonged slow expiration, which is a slow passive and progressive expiration from functional residual capacity to expiratory reserve volume. The obtained lung deflation helps the secretions to flow from the smaller to the larger airways, where cough can move the secretions to the trachea. It is also likely that the immediate improvement in Wang score and wheezing at T30 is due to the mechanical advantage from lung deflation, rather than from secretion drainage.

Nebulizing hypertonic saline before the CPT maneuver induces an osmotic flow of water in the inspissated mucus, which facilitates drainage and reduces edema in the submucosal tissue.[18] The benefits we observed from nebulized hypertonic saline in this study are similar to those of Mandelberg's group; at T150 the Wang score

of the control group showed a significant improvement.[9,10] With the addition of the prolonged slow expirations and provoked cough the results were better in the new-method-CPT group at T30, but similar for the groups at T150.

By contributing actively to a direct and immediate drainage of secretions, the new CPT method reduces some bronchial obstruction symptoms that are usually associated with an increased load of breathing, due to a positive intrathoracic pressure and an increased respiratory rate.[19] The CPT and nebulized hypertonic saline act in synergy. The improvement was cumulative in the new-method-CPT group, with a day-to-day baseline improvement in Wang score significantly better than that in the control group. This trend was observed over 3 winters. The day-to-day effect could result from the viral load reduction in airway secretions, as suggested by Mandelberg. The benefit might also result from hyperventilation and persistent cough after the session. The time required for mucociliary transport of secretions from the smaller to the larger airways could be another explanation for the difference. We suggest that the new CPT method is the cornerstone of a longer-lasting benefit.

Wheezing and cough are common symptoms of bronchial obstruction in childhood. The improvement of the Wang score is directly related to reduction in wheezing (see Table 3). This leads us to believe that mucus drainage in infants is the mainstay of the improvement, as the CPT maneuvers cannot affect edema and bronchospasm, although both are usually associated with wheezing.[20]

Conclusions

Our new CPT method reduced some respiratory symptoms of bronchial obstruction in infants with acute RSV bronchiolitis. A multi-center study is needed to confirm these preliminary results.

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