Title of the article: Chest physical therapy for children hospitalized with acute pneumonia: a randomized controlled trial

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Word count: 1997 words

Key words: Chest physical therapy. Pneumonia. Children. Randomized controlled trial. Effectiveness.
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ABSTRACT

**Background:** The indication of chest physical therapy as an adjunct to treatment of children hospitalized with acute pneumonia remains controversial and there is lack of robust scientific evidence on effectiveness of this modality in these patients.

**Methods:** A randomized controlled trial was conducted in two tertiary hospitals in southern Brazil. Children aged 29 days to 12 years, hospitalized with pneumonia between February and October of 2006 were recruited. Fifty-one patients were randomly allocated to the intervention group (chest physical therapy plus standard treatment for pneumonia) and 47 to the control group (standard treatment for pneumonia alone). The primary outcome was time to clinical resolution. The secondary outcomes were length of hospitalization and duration of respiratory symptoms and signs.

**Results:** There were no significant differences in terms of median time to clinical resolution (4.0 vs 4.0 days, p=0.84) and median length of hospital stay (6.0 vs 6.0 days, p=0.76) between the intervention and control groups. The intervention group had longer median duration of coughing (5.0 vs 4.0 days, p=0.04) and of rhonchi in lung auscultation (2.0 vs 0.5 days, p=0.03) than the control group.

**Conclusions:** Chest physical therapy as adjunct to the standard treatment does not hasten clinical resolution of children hospitalized with acute pneumonia and may prolong duration of coughing and rhonchi.
Main text

Introduction
The indication of chest physical therapy as an adjunct to treatment of children hospitalized with acute pneumonia remains controversial. On the one hand, chest physical therapy has been and continues to be widely applied to these patients in pediatric practice, based on beliefs of the potential benefits of this modality on evacuating inflammatory exudates and tracheobronchial secretion, removing airway obstruction, reducing airway resistance, enhancing gas exchange and reducing the work of breathing.[1-3] On the other hand, there is lack of robust scientific evidence on effectiveness of chest physical therapy in children hospitalized with pneumonia. The British Thoracic Society guidelines for managing pneumonia in childhood recommend that chest physical therapy is not beneficial and should not be performed in children with pneumonia,[4] however, these recommendations are based mainly on the results of two randomized controlled trials, one in adults and another in children.[5, 6] Moreover, the validity of this old clinical trial in children is questionable due to small sample size, exclusion of patients with pneumonia of presumed bacterial origin and inadequate randomization and blinding.[6] Therefore, more data from high quality randomized trials are needed to make a more precise decision on the indication of chest physical therapy for acute pneumonia in childhood.

This randomized controlled trial was conducted to assess the effectiveness of chest physical therapy in children hospitalized with acute pneumonia. We hypothesized that chest physical therapy as adjunct to standard treatment could hasten clinical resolution of children hospitalized with acute pneumonia.

Methods
Study setting
This study was conducted in the pediatric wards of two tertiary hospitals: 30-bed teaching hospital of Federal University of Rio Grande and 30-bed hospital da Santa Casa de Rio Grande. These are two unique hospitals in the city of Rio Grande in southern Brazil, covering a population of approximately 200,000. The ethic committee of the Federal University of Rio Grande (Rio Grande, RS, Brazil) and the ethic committee of the hospital da Santa Casa de Rio Grande (Rio Grande, RS, Brazil) approved the study.

Participants
Children aged 29 days to 12 years old, hospitalized with a diagnosis of acute pneumonia, were assessed for eligibility for this study. The patients were included in the study if they met all of the following clinical and radiological diagnosis criteria for pneumonia:[4, 7] (1) presence of coughing and/or fever; (2) tachypnea, defined as respiratory rate above age-dependent upper limits: <2 months: 60 breaths per minute (bpm); 2–12 months: 50 bpm; >1–5 years: 40 bpm; >5 years: 30 bpm; (3) consolidations and/or infiltrates, associated or not with other findings compatible with pneumonia on chest X-ray. All chest radiographs were interpreted routinely in the Department of Radiology and reviewed by a senior pediatric pulmologist (Z.L). Any disagreement was resolved by discussion with a reference radiologist. We excluded patients who needed a chest drain, who had haemodynamic instability, bone fragility or rib fractures, and any other contraindication to chest physical therapy.[1] The recruitment of participants occurred between February and October of 2006. The parents or legal guardians of each child gave written informed consent before enrollment.

Study design and protocol
This study was a randomized and controlled clinical trial. Simple randomization was performed from a table of random numbers. The recruited participants were randomly allocated to the intervention group or the control group. The intervention group received chest
physical therapy twice daily plus standard treatment for pneumonia until discharge and the control group received standard treatment for pneumonia alone. Each session of chest physical therapy took about 30 minutes, consisted of postural drainage, thoracic squeezing, chest percussion, vibration, cough stimulation and aspiration of secretions (if necessary).[1, 5, 6] The positions for postural drainage were guided by chest X-ray to allow more effective drainage of tracheobronchial secretion and inflammatory exudates in the most affected areas. [1, 6] The same certified physiotherapist (C.P) administered chest physical therapy to all patients.

The standard treatment for pneumonia in each patient was administered by the attending pediatricians, based on the recommendations of Brazilian guidelines for diagnosis and treatment of pneumonia.[7] It included antibiotic therapy, fluid therapy and oxygen therapy if needed. The decision of hospital discharge was also made by the attending pediatricians. All attending pediatricians were blinded to group assignment and study protocol.

The patients were assessed at enrollment and every afternoon between 5:00 and 6:00pm by one of 4 investigators, using a pre-codified questionnaire. The same investigator was responsible for assessment of each patient from enrollment to discharge. Patient’s assessment included respiratory symptoms, respiratory signs (respiratory rate, chest in-drawing, nasal flaring, cyanosis and lung auscultation) and arterial oxygen saturation measured by pulse oximetry. All 4 investigators received adequate training in assessment of the patient, especially in measuring respiratory rate and arterial oxygen saturation, in observing chest in-drawing and in lung auscultation. The standard technique for measurement of respiratory rate and arterial oxygen saturation was same as previously reported.[8] The definition of adventitious sounds in lung auscultation was based on the recommendations of 1985 International Symposium on Lung Sounds.[9] The inter-observer agreement between 4 investigators and a senior pediatric pulmologist (Z.L) regarding observation of respiratory signs (tachypnea, chest in-drawing, rhonchus, wheezes, fine crackles and coarse crackles) was evaluated and Kappa indexes were 0.53, 0.63, 0.48, 0.70, 0.60 and 0.47 respectively. Daily maximum body temperature was noted by the investigators based on patient’s nursing record. The patient’s axillary temperature was measured by the attending nurses every 3 hours throughout the hospital stay. All investigators and nurses were blinded to group assignment and study protocol. The different schedules were arranged for investigators and physiotherapist to avoid their chance encounter at patient’s bedside.

**Outcome measures**

The primary outcome was time to clinical resolution, being defined as the number of days needed for patient to present with the following clinical parameters: afebrile (daily maximum body temperature<37.5°C), absence of signs of the severity (chest in-drawing, nasal flaring and cyanosis), normal respiratory rate and arterial oxygen saturation equal to or higher than 95%. Secondary outcomes were length (days) of hospital stay and persistence (days) of respiratory symptoms and signs (fever, cough, wheezing, tachypnea, chest in-drawing, adventitious sounds in lung auscultation and arterial oxygen saturation below 95%).

**Sample size**

The Sample size was determined on the assumption that mean time to clinical resolution (mean±SD) in the control group were 6±1.5 days. [6] To detect a clinically-relevant reduction of one day in the time to clinical resolution, we needed 47 participants in each group (two-sided alpha of 5% and power of 90%).

**Statistical analysis**

Statistical analysis was performed using STATA 8.0 program (Stata Corporation, Texas, USA, 2003). The χ² test was used for analysis of dichotomous data. Unpaired Student’s t-test or Mann-Whitney rank-sum test were used for analysis of continuous data as appropriate. Analyses were based on the intention-to-treat principle. In the additional analysis, we excluded the possible cases of acute bronchiolitis, that is, patients who were younger than 2 years old and presented with wheezes in lung auscultation at enrollment. The explanatory
analysis was also performed to verify the potential changes in the results. Two-tailed P value <0.05 was considered as statistically significant.

**Results**

One hundred and ten children were assessed for eligibility during the study period and 98 were included for the trial (Figure 1). Of 98 recruited patients, 51 were randomly allocated to the intervention group and 47 to the control group. Table 1 summarizes characteristics of all 98 patients at enrollment and randomization. There were not significant differences between the intervention and control groups in terms of the baseline characteristics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Intervention group (n = 47)</th>
<th>Control group (n = 42)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>44.0 (31.6-56.4)</td>
<td>32.2 (22.5-41.9)</td>
<td>0.14</td>
</tr>
<tr>
<td>Male sex</td>
<td>29 (61.7)</td>
<td>24 (57.1)</td>
<td>0.66</td>
</tr>
<tr>
<td>Low birthweight (&lt;2500g)</td>
<td>5 (10.6)</td>
<td>4 (9.5)</td>
<td>0.86</td>
</tr>
<tr>
<td>Prematurity (&lt;37 weeks)</td>
<td>8 (17.0)</td>
<td>6 (14.2)</td>
<td>0.72</td>
</tr>
<tr>
<td>Maternal smoking</td>
<td>17 (36.1)</td>
<td>17 (40.4)</td>
<td>0.67</td>
</tr>
<tr>
<td>Respiratory symptoms and signs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coughing</td>
<td>46 (97.8)</td>
<td>38 (92.6)</td>
<td>0.24</td>
</tr>
<tr>
<td>Fever</td>
<td>45 (95.7)</td>
<td>37 (90.2)</td>
<td>0.30</td>
</tr>
<tr>
<td>Parent’s reported wheezing</td>
<td>31 (65.9)</td>
<td>24 (58.5)</td>
<td>0.47</td>
</tr>
<tr>
<td>Respiratory rate (bpm)</td>
<td>45.0 (40.9-49.1)</td>
<td>45.8 (41.6-50.1)</td>
<td>0.78</td>
</tr>
<tr>
<td>Chest in-drawing</td>
<td>24 (51.0)</td>
<td>22 (53.6)</td>
<td>0.80</td>
</tr>
<tr>
<td>Fine crackles</td>
<td>16 (34.0)</td>
<td>11 (26.8)</td>
<td>0.46</td>
</tr>
<tr>
<td>Coarse crackles</td>
<td>17 (36.1)</td>
<td>19 (46.3)</td>
<td>0.33</td>
</tr>
<tr>
<td>Rhonchi</td>
<td>9 (19.2)</td>
<td>6 (14.6)</td>
<td>0.57</td>
</tr>
<tr>
<td>Wheezes</td>
<td>13 (27.6)</td>
<td>5 (12.2)</td>
<td>0.07</td>
</tr>
<tr>
<td>Chest x-ray findings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consolidation</td>
<td>39/45 (86.7)</td>
<td>35/39 (89.7)</td>
<td>0.66</td>
</tr>
<tr>
<td>Hyperinflation</td>
<td>6/45 (13.3)</td>
<td>5/39 (12.8)</td>
<td>0.95</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>5/45 (11.1)</td>
<td>6/39 (15.4)</td>
<td>0.56</td>
</tr>
<tr>
<td>Arterial oxygen saturation</td>
<td>95.0 (94.3-95.7)</td>
<td>95.7 (95.0-96.4)</td>
<td>0.15</td>
</tr>
<tr>
<td>Antibiotic therapy</td>
<td>47 (100.0)</td>
<td>42 (100.0)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Values expressed as mean (IC 95%) or N (%)

Table 2 compares clinical evolution between the intervention group and the control group. The intervention group had longer median duration of coughing (5.0 vs 4.0 days, p=0.04) and of rhonchi in lung auscultation (2.0 vs 0.5 days, p=0.03) than the control group. There were no significant differences between the two groups in terms of other parameters of the clinical evolution.

No significant changes were observed in the results when additional analysis (excluding 12 patients who were younger than 2 years old and presented with wheezes at enrollment) and explanatory analysis (excluding 7 patients in the control group who received chest physical therapy indicated by attending pediatricians) were performed.

**Discussion**

This randomized trial failed to confirm that chest physical therapy as adjunct to standard treatment could hasten clinical resolution of children hospitalized with acute pneumonia. The time to clinical resolution and the length of hospital stay were similar between the intervention group and the control group. Moreover, this study showed that the patients who received chest physical therapy had had prolonged duration of coughing and...
rhonchi in lung auscultation. However, the persistence of these respiratory symptoms and signs may not necessarily represent an unfavorable clinical evolution. Coughing might be induced by physiotherapist since it was an essential component of chest physical therapy. Rhonchus, a typical “secretion sound” in lung auscultation might be prolonged by chest physical therapy as this modality could dislodge tracheobronchial secretion and produce this adventitious sound. In this sense, chest physical therapy might effectively mobilize tracheobronchial secretion in this group of children, but failed to modify the clinical evolution of acute pneumonia assessed by time to clinical resolution, length of hospital stay, and persistence of other individual clinical parameter like fever, respiratory rate, chest in-drawing and arterial oxygen saturation.

Table 2. Effects of chest physical therapy on clinical evolution of children hospitalized with acute pneumonia

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Intervention group (n = 47)</th>
<th>Control group (n = 42)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to clinical resolution</td>
<td>4.0 (2.0-7.0)</td>
<td>4.0 (3.0-6.0)</td>
<td>0.84</td>
</tr>
<tr>
<td>Length of hospital stay</td>
<td>6.0 (4.0-9.0)</td>
<td>6.0 (4.0-8.0)</td>
<td>0.76</td>
</tr>
<tr>
<td>Time to normal respiratory rate</td>
<td>3.0 (0-7.0)</td>
<td>3.0 (1.0-6.0)</td>
<td>0.75</td>
</tr>
<tr>
<td>Time to normal arterial oxygen saturation (≥95%)</td>
<td>1.0 (0-2.0)</td>
<td>0.5 (0-2.0)</td>
<td>0.98</td>
</tr>
<tr>
<td>Time to normal lung auscultation</td>
<td>4.0 (3.0-6.0)</td>
<td>4.0 (2.0-6.0)</td>
<td>0.28</td>
</tr>
<tr>
<td>Duration of fever</td>
<td>2.0 (0-2.0)</td>
<td>1.0 (0-3.0)</td>
<td>0.78</td>
</tr>
<tr>
<td>Duration of coughing</td>
<td>5.0 (4.0-8.0)</td>
<td>4.0 (3.0-6.0)</td>
<td>0.04</td>
</tr>
<tr>
<td>Duration of parent’s reported wheezing</td>
<td>1.5 (0-5.0)</td>
<td>1.0 (0-3.5)</td>
<td>0.29</td>
</tr>
<tr>
<td>Duration of fine crackles</td>
<td>0 (0-2.0)</td>
<td>0 (0-2.0)</td>
<td>0.72</td>
</tr>
<tr>
<td>Duration of coarse crackles</td>
<td>2.0 (0-4.0)</td>
<td>1.0 (0-3.0)</td>
<td>0.83</td>
</tr>
<tr>
<td>Duration of wheezes</td>
<td>0 (0-5.0)</td>
<td>0 (0-4.0)</td>
<td>0.62</td>
</tr>
<tr>
<td>Duration of rhonchi</td>
<td>2.0 (0-4.0)</td>
<td>0.5 (0-2.0)</td>
<td>0.03</td>
</tr>
<tr>
<td>Duration of chest in-drawing</td>
<td>2.0 (0-3.0)</td>
<td>2.0 (0-3.0)</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Number of days expressed as median (interquartile range)

No beneficial effect of chest physical therapy in children hospitalized with viral pneumonia has been reported by one clinical trial, in spite of serious methodological limitations mentioned previously.[6] Moreover, prolonged fever was observed in the intervention group. The similar finding was also reported by the other randomized trial in adults with primary pneumonia.[5] The spread of the infiltrates and physical activity associated with chest physical therapy were speculated to explain prolonged fever in the patients who received this modality. In the present trial, the intervention group had longer median duration of fever than the control group (2.0 vs 1.0 days), however, this difference was not statistically significant (p=0.78).

The data derived from this randomized trial support the recommendations of the British Thoracic Society guidelines regarding the indication of chest physical therapy in children with acute pneumonia,[4] that is, chest physical therapy is not beneficial and should not be performed in these patients. However, these recommendations may not be suitable for special groups of children with acute pneumonia, like those who have impaired mucociliary clearance and who have complications such as atelectasis and pleural effusion needing a chest drain. Future randomized trials should focus on these special groups of patients.

Some methodological aspects of this trial deserve special comments. Firstly, no placebo is available to blind those involved in a trial of physical therapy and it may be the source of performance and observation bias.[10] To minimize these potential bias, all
investigators who assessed the patients and all attending pediatricians and nurses were blinded to group assignment and study protocol. Secondly, no standard protocol of physical therapy is well defined for special respiratory disease and the “art” of this modality may introduce a number of personal and uncontrollable factors. In this trial, the protocol of physical therapy was defined \textit{a priori}, based on the experiences of the previous studies and on the potential benefits of each component on acute pneumonia.[1, 5, 6, 11] To avoid inter-individual variation caused by “art” of physical therapy, the same physiotherapist administered this modality to all patients. Thirdly, the outcomes currently used to assess the effectiveness of chest physical therapy, such as radiolabelled aerosols, chest x-ray, sputum volume, oxygen saturation and pulmonary function testing, are considered unreliable or impractical, specially in pediatric population.[2] We used the time to clinical resolution as the primary outcome since we expected that chest physical therapy could hasten clinical evolution of children hospitalized with acute pneumonia. This variable consists of various relevant and relatively accurate signs which reflect the severity and evolution of pneumonia.[4, 7, 12] Therefore, this outcome may be more reliable and objective than the length of hospital stay or duration of any individual symptom or sign to represent clinical evolution of acute pneumonia in childhood.

**Acknowledgements**

Cristina Paludo, Carla S. Lincho and Jorge A. Bergamin received grants from the following Brazilian government research support agencies: the Coordination for the Improvement of Higher Education Personnel (CAPES), the National Council for the Scientific and Technologic Development (CNPq) and the Research Assistance Fund of Rio Grande do Sul (FAPERGS).

The authors thank Raúl Mendoza-Sassi for advice on statistical analysis.
References
1 Balachandran A, Shivbalan S, Thangavelu S. Chest Physiotherapy in Pediatric Practice. *Indian Pediatrics* 2005;42:559-68.
Figures

Figure 1. Flow diagram of the trial

Patients assessed for eligibility (n=110)

12 excluded
  10 did not meet inclusion criteria
  2 met an exclusion criterion

Randomization (n=98)

Intervention group (n=51)

4 were withdrawn, with incomplete follow-up data
  2 had hospital discharge/transfer before the second assessment
  2 met an exclusion criterion

47 were analysed

Control group (n=47)

7 patients received chest physical therapy indicated by attending pediatricians
5 were withdrawn, with incomplete follow-up data
  2 had hospital discharge before the second assessment
  3 met an exclusion criterion

42 were analysed
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