Chest Physiotherapy Fails to Prevent Postoperative Atelectasis in Children After Cardiac Surgery

H. DAVID REINES, M.D., ROBERT M. SADE, M.D., BARBARA F. BRADFORD, M.D., JOHN MARSHALL, R.R.T.

In a prospective, randomized study, the effectiveness of chest physiotherapy (CPT) was evaluated in preventing postoperative atelectasis in children after heart surgery. Postoperative clinical variables and chest x-ray findings of atelectasis were compared in two groups: 19 patients receiving CPT and 25 patients not receiving CPT (NCPT). Chest physiotherapy was associated with significantly more frequent ($p < 0.01$) and more severe ($p < 0.01$) atelectasis than NCPT. Atelectasis was not significantly associated with temperature elevation, age, or presence of preoperative left-to-right shunt.

From the Departments of Surgery, Anesthesiology, and Radiology, Medical University of South Carolina, Charleston, South Carolina

ATELECTASIS AND PNEUMONIA are common postoperative complications, occurring in 21 to 70% of surgical patients.[1,2] Many techniques have been used to treat these problems and most have been discarded as ineffective. During the past decade, chest physiotherapy (CPT) has become more popular in this country after encouraging results in Britain.[3] Questions regarding the efficacy of chest physiotherapy, the scarcity of qualified personnel, and the cost of medical care led us to study chest physiotherapy in the prevention of postoperative atelectasis.

Materials and Methods

Fifty consecutive children (ages 3 months to 9 years) undergoing cardiac surgery for congenital heart disease (Table 1) were randomized into two groups. The first group (CPT) received routine postoperative pulmonary toilet that included deep breathing, suctioning for airway secretions, coughing, and chest physiotherapy every four hours by a qualified respiratory therapist. Chest physiotherapy consisted of postural drainage with vibration and cupping in Trendelenburg, reverse Trendelenburg, and right and left lateral decubitus positions. These maneuvers were performed for a maximum of 20 minutes. The second group (NCPT) received only suctioning, deep breathing, and coughing without chest physiotherapy.

All care was standardized by methods previously described.[4] Temperature and respiratory rate were recorded every four hours and as necessary. Chest x-rays were obtained immediately after operation and three subsequent mornings, or more frequently if deemed necessary by the cardiac surgical service. Six patients who did not survive the study period or did not receive the designated treatment were eliminated, leaving 44 patients for statistical analysis.

All x-rays were interpreted by a pediatric radiologist without knowledge of the group to which each patient

TABLE 1. *Diagnosis*

	CPT*	NCPT†	Significance
Open heart	13	17	NS
Tetralogy of Fallot	3	3	
Transposition of great arteries	1	1	
Atrioventricular canal	2	1	
Ventricular septal defect	4	4	
Atrial septal defect	1	5	
Aortic stenosis	2	1	
Complex malformations	0	2	
Closed heart	6	8	NS
Coarctation of aorta	3	1	
Patent ductus arteriosus	2	4	
Pulmonic stenosis	1	3	

* CPT: chest physiotherapy.
† NCPT: no chest physiotherapy.

Request reprints: H. David Reines, M.D., Department of Anesthesiology/Surgery, Medical University of South Carolina, 171 Ashley Avenue, Charleston, SC 29425.

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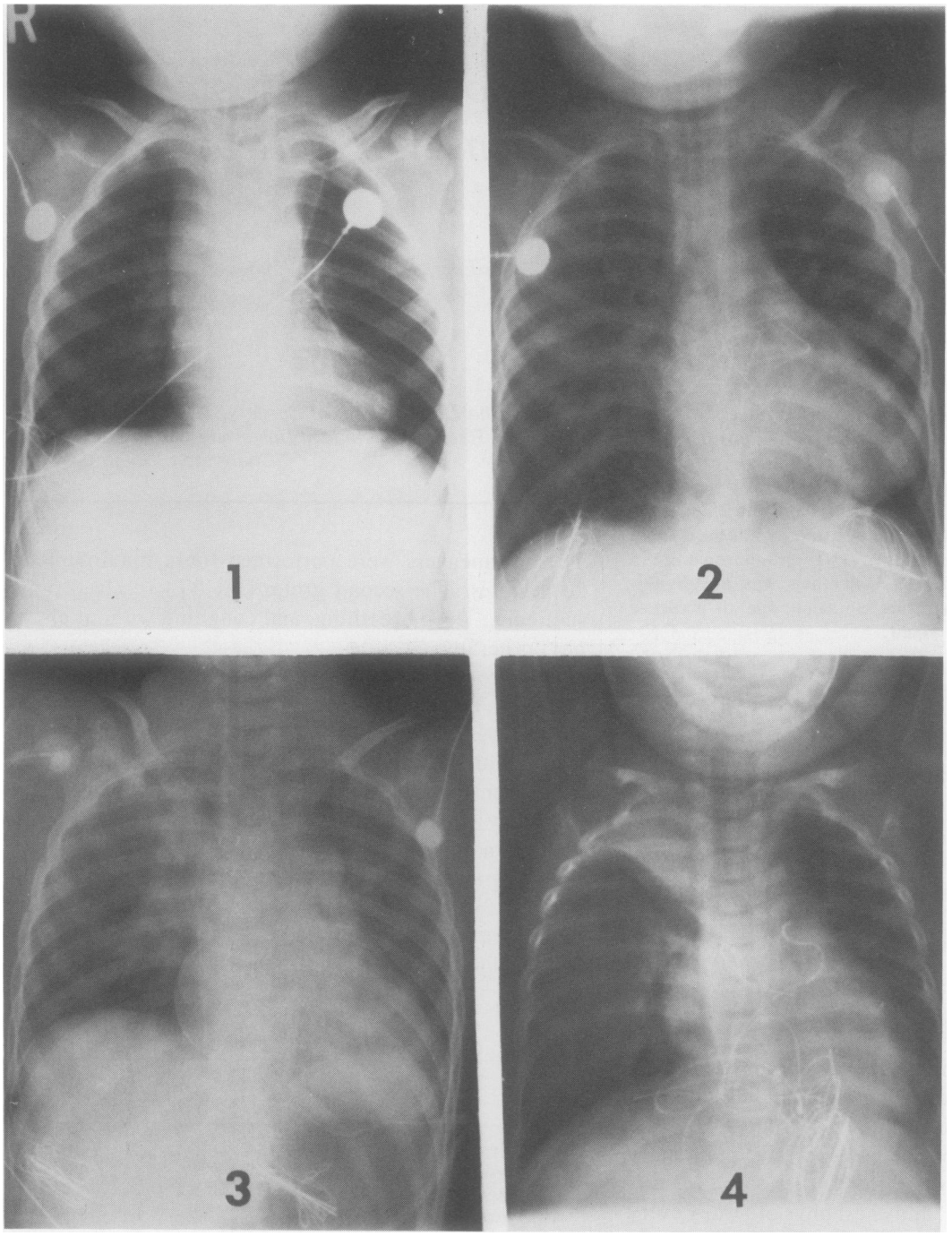

FIG. 1. Examples of semiquantitative chest x-ray rating scale. 1. Clear chest x-ray. 2. Segmental atelectasis (right middle and left lower lung field). 3. Diffuse atelectasis (several lobes with atelectasis, none totally collapsed). 4. Lobar atelectasis (complete collapse of right upper lobe).

belonged. Radiographs were scaled semiquantitatively according to the severity of atelectasis: (1) none, (2) segmental, (3) diffuse, and (4) lobar (Fig. 1).

Data were then analyzed by chi square test of independence or one-way analysis of variance where appropriate.

Informed consent was obtained from parents or guardians. This study was approved by our Institutional Review Board for Human Research (No. HR 1064).

Results

Forty-four children satisfied the criteria for inclusion in the analysis. The age distribution for the CPT and

NCPT groups was similar, as was the distribution of types of incisions (all patients had either sternotomy or lateral thoracotomy), and the presence of a preoperative left-to-right shunt (Table 2). All mean values are accompanied by standard error of the mean.

The daily peak temperature and sleeping respiratory rate were not statistically different ($p > 0.05$) in the two groups (Table 3). The CPT group developed atelectasis significantly more frequently and more severely than the NCPT group. Because a few patients had atelectasis before operation, the preoperative x-ray grade was subtracted from the highest postoperative grade, and the resulting grade difference was compared (Table 3).

The severity of atelectasis was unrelated to age, the presence before operation of left-to-right intracardiac shunting, or to degree of temperature elevation (Table 4). Patients receiving CPT had a prolonged (9.7 ± 4.3 days) hospital stay compared to the NCPT group (7.5 ± 3.0 days; $p = 0.05$). Pneumonia was diagnosed by fever, leukocytosis, cultures, radiologic findings, and clinical course in two patients in the NCPT group and one in the CPT group. This difference was not statistically significant.

Discussion

Chest physiotherapy has long been used with many other modalities as an adjunct to prevent and treat atelectasis and pneumonia in postoperative patients.[5] Despite widespread use of these therapies, an increasing body of data is being published that questions the effectiveness of CPT, intermittent positive pressure breathing (IPPB), and incentive spirometry.[2,6-10]

Many explanations are offered for the development of postoperative atelectasis and pneumonia. Hypoventilation and splinting, accumulation of mucous plugs, and deactivation of surfactant are proposed mechanisms.[11,12] Pain, cardiopulmonary bypass, prolonged anesthesia, and inspissation of secretions may contribute to occurrence of atelectasis after surgery. Marked atelectasis has been noted in 20–60%[7] of cardiac surgical patients. After upper abdominal surgery, up to 70% of adults develop atelectasis.[1,2,13]

Chest physiotherapy has been shown to be effective by increasing suptum production in chronic bronchitis.[14,15] It has been used with good results in treating cystic fibrosis and bronchiectasis.[16] The treatment of mucous plug-induced atelectasis with CPT has also been successful.[17,18] Recent data have raised questions about the efficacy of CPT for many other clinical situations; however, Graham and Bradley[19] recently found no benefit of IPPB and CPT in the treatment of established pneumonia. Despite the improvement in oxygenation during CPT in some neonates that was noted by Finer and Boyd,[20] Fox and co-workers[8] found severe hypoxemia in several infants without concomitant improvement in other pulmonary parameters following percussion and suctioning. Connors[6] documented a temporary fall in P_aO_2 during CPT in patients without sputum production and warned of the potential dangers of this technique in acutely ill patients. Craven[9] demonstrated postoperative pulmonary complications in 15 of 17 patients studied while receiving CPT, while Lazlo[2] found no benefit from CPT in postoperative patients who did not have chronic bronchopulmonary disease.

Our study demonstrates an increase in the incidence of radiologic postoperative atelectasis after cardiovascular procedures in children who receive CPT. We recognize that some overlap of severity exists between our radiologic grades 2, 3, and 4, making the semiquantitative rating of x-rays less meaningful than it would be if accurate quantitation of atelectasis were possible. Our finding that CPT may increase atelectasis is still valid,

TABLE 2. *Characteristics of the Groups*

	CPT*	NCPT†	Significance
No. patients	19	25	NS
Age (months)	48 ± 12	46 ± 7	NS
Incision site (no. patients) (sternotomy/lateral thoracotomy)	13/6	18/7	NS
Lesion included left-to-right shunt (no. patients)	11	16	NS

* CPT: chest physiotherapy.
† NCPT: no chest physiotherapy.

TABLE 3. *Results: CPT vs. NCPT*

	CPT*	NCPT†	Significance
Highest postoperative temperature (C)	38.5 ± 0.1	38.4 ± 0.1	NS
Daily peak sleeping respiratory rate (min^{-1})	30 ± 2	29 ± 2	NS
Atelectasis: highest postop grade	3.2 ± 0.2	2.8 ± 0.2	$p < 0.01$
Highest postop-preop grade	2.1 ± 0.2	1.5 ± 0.2	$p < 0.01$
No. pts developing atelectasis	13/19 (68.4%)	8/25 (32.0%)	$p < 0.01$

* CPT: chest physiotherapy.
† NCTP: no chest physiotherapy.

TABLE 4. *Results: Other Variables*

	Age Related to Atelectasis				
	Age (Years)				
	0–1	1–3	3–6	>6	
No. patients	11	12	12	9	
Atelectasis grade (highest postop–preop)	1.7 ± 0.4	1.8 ± 0.3	1.8 ± 0.3	1.4 ± 0.2	NS
	Diagnosis Related to Atelectasis				
	L–R Shunt		No L–R Shunt		
No. patients	25		19		
Atelectasis grade (highest postop–preop)	1.7 ± 0.2		1.7 ± 0.2		NS
	Grade of Atelectasis Related to Temperature				
	X-ray Grade				
	1	2	3	4	
No. x-rays	49	35	54	20	
Peak temperature on day x-ray taken	37.8 ± 0.1	38.0 ± 0.1	38.0 ± 0.1	38.1 ± 0.2	NS

however, since the number of patients who remained free of atelectasis was significantly greater in the NCPT group (Table 3).

Several explanations can be proposed for this apparent reversal of expected results. An increase in ventilation-perfusion mismatch may be caused by change in position and blood flow pattern. This mismatch may be further increased by mucous moving from peripheral to central airways.[6] Lung compression from percussion, especially on the child's compliant thorax, may cause physical collapse of airways or force air out of ventilated segments and allow them to collapse. Another explanation for the increase in atelectasis with CPT may be that the pain induced by CPT leads to splinting and decrease in functional residual capacity, resulting in collapse. Hypoventilation in Trendelenburg position may also play a role.

We have made other interesting observations. We had expected the severity of atelectasis to be greater in infants and in children with lesions that included large left-to-right shunts. Atelectasis was related neither to age nor to presence of left-to-right shunt. We had expected the fever associated with atelectasis to be higher with greater degrees of collapse. This also was not the case, even in association with lobar collapse. Therefore, we are now reluctant to attribute fever in our postoperative patients to atelectasis.

We have demonstrated no benefit from the use of CPT routinely in our postoperative pediatric cardiac surgical patients. Furthermore, CPT may be harmful by increasing the incidence of atelectasis in this group. The use of a treatment that lacks efficacy is not justified. Therefore, CPT in children after cardiovascular surgery is unjustified and is also expensive, costing $60–100 per day ($15 per treatment) in our institution. The discontinuation of this and other therapies of unproven worth, especially prophylactic IPPB, can save millions of dollars in medical costs nationally each year.

Chest physiotherapy should be reserved for those patients in whom its benefits have been proven, especially patients with large amounts of sputum production and mucous plugging.[21] We recommend it be omitted from routine use for the prophylaxis of atelectasis for the postoperative pediatric cardiac surgical patient.

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