Physiotherapy Theory and Practice (1994) **10**, 143–152

#3751 RCT physiotherapy lung exercises

Are breathing and coughing exercises necessary after coronary artery surgery?

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To investigate whether the incidence of post-operative pulmonary complications was significantly higher in a control group compared with treament groups receiving prophylactic chest physiotherapy after coronary artery surgery, 120 patients completed a randomised controlled study. The patients in group 1 ($n=40$) received no pre- or post-operative chest physiotherapy. The patients in group 2 ($n=40$) were seen pre-operatively for education and instruction in breathing and coughing exercises and post-operatively received supervision and assistance from a physiotherapist in performing these exercises. The frequency of chest physiotherapy was twice per day on the first two post-operative days and once per day on the third and fourth post-operative days. The patients in group 3 ($n=40$) received the same chest physiotherapy as those in group 2 except that the frequency was increased to four times per day on the first two post-operative days and twice per day on the third and fourth post-operative days. The patients in groups 2 and 3 were also advised to perform breathing and coughing exercises independently every hour. Nine patients (7.5%) developed clinically significant post-operative pulmonary complications. Pre-operative lung function was lower and hypoxaemia was more severe in the early post-operative period in these nine patients compared with the remaining patients. The incidence and severity of fever, hypoxaemia, chest x-ray abnormalities and clinically significant post-operative pulmonary complications were not significantly higher in the control group. The findings of this study suggest that the necessity for prophylactic chest physiotherapy after routine coronary artery surgery should be reviewed.

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Accepted for publication March 1994

INTRODUCTION

Although chest physiotherapy is routinely used after coronary artery surgery with the aim of preventing pulmonary complications, there have been relatively few studies which have evaluated its effectiveness (Vraciu and Vraciu, 1977; Iverson, Ecker, Fox and May, 1978; Gale and Sanders, 1980; Oulton, Hobbs and Hicken, 1981; Dull and Dull, 1983; Stock et al, 1984; Rau,

Thomas and Haynes, 1988; Jenkins et al, 1989; Pinilla et al, 1990; Oikkonen et al, 1991). In these studies, the incidence of post-operative pulmonary complications was similar for patients who received various regimens of treatment such as breathing and coughing exercises, incentive spirometry, intermittent positive pressure breathing and periodic continuous positive airway pressure. Dull and Dull (1983) and Jenkins et al (1989) found that breathing exercises or incentive spirometry did not add to the effectiveness of a regimen of early mobilisation and coughing.

To date, no study has included a control group of patients who received no chest physiotherapy, so it is not certain whether any prophylactic chest physiotherapy is required after routine coronary artery surgery. The aim of the present study was to investigate whether the incidence of clinically significant pulmonary complications was significantly higher in a control group compared with treatment groups receiving prophylactic breathing and coughing exercises after coronary artery surgery.

METHODS

Subjects

Consecutive patients undergoing elective coronary artery surgery who gave informed written consent were considered for inclusion in the study. Patients who were unable to understand written or spoken English were excluded. The patients were randomly allocated to one of three groups. Approval for the study was obtained from the Human Ethics Committee of the Royal Adelaide Hospital. The following criteria were used for withdrawing patients from the study: the necessity for more than 24 h mechanical ventilation post-operatively or the development of neurological or cardiac complications which interfered with the patient's ability to cooperate with treatment.

General management

All patients viewed a video pre-operatively which contained general information regarding the pre- and post-operative management. This included information that a physiotherapist would visit the patient pre-operatively to explain the need for chest physiotherapy and that, with the additional assistance of nursing staff, patients would perform breathing and coughing exercises post-operatively to prevent chest infections. In practice, however, nursing staff were instructed not to perform any breathing and coughing exercises with patients involved in the study, and the physiotherapists only visited pre-operatively and performed post-operative chest physiotherapy on patients in groups 2 and 3.

In the period of post-operative mechanical ventilation, the patients were nursed from side to side with the bed flat. No physiotherapy was given to the patients while they remained intubated. Following extubation, the patients were positioned in supine or from side to side with the bed head elevated 45°. Patient position was altered every 2 h. The patients followed the normal mobilisation protocol used at the Royal Adelaide Hospital, which consisted of sitting out of bed on day 2, walking from day 3 and climbing stairs on day 7. This protocol was supervised by the nursing staff. The medical and nursing staff involved in the study were not informed of the patients' groups.

Groups

Group 1

This comprised the control group. No pre- or post-operative chest physiotherapy was given to patients in this group. The patients were seen by a physiotherapist on the first post-operative day and again on the fourth or fifth post-operative day to ensure that they had regained their pre-operative active range of shoulder girdle mobility. The patients were encouraged to carry out active exercises independently to maintain their shoulder girdle mobility from the first post-operative day onwards.

Group 2

Pre-operatively, the patients in this group were educated and instructed in deep breathing and coughing exercises by a physiotherapist. Post-

operative physiotherapy commenced on the morning of the first day after surgery. The frequency of treatment by the physiotherapist was twice per day on the first two post-operative days and once per day on the third and fourth post-operative days. During any one treatment session, the patient performed 3–5 deep breaths interspersed with periods of quiet breathing. Following this the patient coughed or huffed 2–3 times with wound support using their hands or a pillow. Generally, the patients were treated in their resting position (supine or on their side with the bed head elevated 45°). However, if required, the patient was sat forwards to aid in effective coughing. The deep breaths were verbally encouraged by the physiotherapist and started from resting end-expiratory volume. This cycle was repeated at least twice or until the patient's cough sounded dry. As well as this treatment, the patients were requested to perform these breathing and coughing exercises every waking hour. If breathing and coughing exercises alone were not effective in clearing excessive or retained pulmonary secretions, the physiotherapist was able to use additional techniques such as selective positioning to assist removal of pulmonary secretions and chest wall vibrations.

The patients were encouraged to perform exercises to maintain full active shoulder girdle mobility as noted for group 1.

Group 3

Physiotherapy for group 3 patients was the same as for the patients in group 2 except that the frequency of supervised treatment was increased to four times per day on the first two post-operative days and twice daily on the third and fourth post-operative days. The patients were encouraged to achieve full active shoulder girdle mobility as noted for group 1.

Measurements

Prior to surgery, each patient's age, gender, height and weight were recorded and body mass index [BMI; weight (kg)/height $(m)^2$] calculated. History and symptoms of pulmonary disease and other relevant past medical history were ascertained. Patients were classified as ex-smokers if they had stopped smoking at least 6 weeks prior to surgery (Pearce and Jones, 1982). A calibrated portable spirometer (Pony model, Cosmed) was used to measure forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV_1), peak expiratory flow (PEF) and forced expiratory flow between 25 and 75% of vital capacity ($FEF_{25-75\%}$). The highest of three satisfactory FVC manoeuvres performed with the patient sitting in a chair or on the edge of the bed and wearing a noseclip was recorded.

Data obtained from the operation records included the number of grafts performed, conduit(s) used and duration of cardiopulmonary bypass and anaesthesia. The time from completion of anaesthesia to extubation, medication administered and duration of post-operative hospital stay were also recorded.

Oral temperature was recorded pre-operatively and, on the first and fourth post-operative days, the maximum oral temperature was recorded from the nursing observation charts. The criterion for the presence of fever was an oral temperature of at least 38°C (Pien, Ho and Fergusson, 1982).

Medical staff who were blind to the composition of the patient groups collected arterial blood samples pre-operatively and on days 1 and 4 post-operatively. The absolute values of the partial pressure of oxygen in arterial blood (paO_2), the partial pressure of carbon dioxide in arterial blood ($paCO_2$) and pH were measured. The inspired fraction of oxygen (FiO_2) was recorded at every measurement, enabling the paO_2/FiO_2 to be calculated. Following surgery, this ratio was expressed as a percentage of the pre-operative value.

Chest x-rays were taken pre-operatively and on days 1 and 4 post-operatively. A radiologist (M.W.), who was blind to the composition of the patient groups, evaluated the extent of atelectasis, consolidation or other pulmonary infiltrate and scored this as: 0, no abnormality; 3, minimal; 7, moderate; 15, major. Each lung was scored separately and the total score calculated. The location and type of abnormality were recorded, as was the presence of other x-ray abnormalities.

The measurements noted above were taken

pre-operatively to allow the identification of pre-existing abnormalities. On the first post-operative day they were used as an indication of the patients' status as a result of surgery, and on the fourth post-operative day to reflect the effect of the presence or absence of prophylactic chest physiotherapy.

Based on information from the resident medical staff and his own examination, the cardiologist (J.M.) affiliated with the Cardiothoracic Surgical Unit identified patients with clinically significant pulmonary complications which required that the patient no longer remain in his or her allocated group but receive definitive chest physiotherapy. The cardiologist reviewed all patients on a regular basis and was unaware of the groups to which the patients had been assigned.

Statistical analyses

Analyses were performed using the JMP statistical software package on a Macintosh Powerbook 170 computer. Log-linear modelling was used for categorical data, analysis of variance techniques for continuous scores and non-parametric tests (Wilcoxon/Kruskal-Wallis tests) where skewed distributions were encountered. Probability values of less than 0.05 were considered significant.

Radiologist intra-examiner reliability study

To examine the intra-examiner reliability, the radiologist assigned scores to 33 chest x-rays obtained from 12 patients who had undergone coronary artery surgery and repeated this procedure 6–8 weeks later. The radiologist achieved the same score for 29 films (88%) and was within one grade for the other four films (12%) ($\kappa = 0.84$). This represented good intra-examiner reliability.

RESULTS

Initially, 120 patients were recruited to the study. Of these, seven were withdrawn in the immediate post-operative period (two from group 1, three from group 2, two from group 3). The reasons for withdrawal were the need for more than 24 h mechanical ventilation post-operatively for four patients and neurological complications in three patients, one of whom subsequently died as a result of a peri-operative cerebrovascular accident. These seven patients were replaced so that the number of patients in each group remained the same.

Patient profiles

Descriptive data, pre-operative lung function, operative and post-operative data for the 120 patients who completed the study are given in Table 1. The mean ($\pm$SD) age of the patients studied was 62.0 ± 9.4 years, 81.7% of whom were male. Pre-operative patient profiles, including lung function, did not differ significantly between groups. The internal mammary artery was used as the sole conduit or in combination with a saphenous vein graft in 83 patients (69.2%). Three patients (two in group 1, one in group 2) received bilateral internal mammary artery grafts and five patients (two in group 1, two in group 2, one in group 3) had a valve replacement in addition to coronary artery surgery. The pleura was opened in six patients (two in group 1, one in group 2, three in group 3). Six patients who were operated on for control of haemorrhage were not withdrawn from the study as extubation occurred within 24 h of completion of the initial anaesthetic. Operative and post-operative profiles were not significantly different between groups.

The mean results for oral temperature, arterial blood gas analyses, chest x-ray scores and the incidence of fever are given in Table 2. There were no significant differences between groups at any stage in the mean temperature or the incidence of fever. On day 1 all patients were receiving supplemental oxygen, whereas by day 4 most patients were breathing room air. On day 1 the mean ($\pm$SD) paO_2/FiO_2 was significantly reduced to $51.2 \pm 18.5\%$ of the pre-operative value ($P<0.001$). Although oxygenation had improved by day 4, the paO_2/FiO_2 was still significantly reduced compared with pre-

Table 1
Profiles of the patients completing the study[a]

	Group 1 ($n=40$)	Group 2 ($n=40$)	Group 3 ($n=40$)
Pre-operative data			
Gender, F/M (n)	7/33	7/33	8/32
Age (years)	62±11	61±9	63±8
BMI	26.3±3.3	26.7±3.9	27.0±2.9
Respiratory history			
Smokers (n)	5	5	8
Ex-smokers (n)	16	21	14
Non-smokers (n)	19	14	18
Pack years (n)	17±21	26±30	16±22
Using bronchodilators (n)	7	9	4
Pulmonary function			
FVC (l)	3.55±0.9	3.49±0.8	3.46±0.9
(% pred)	92.8±12.3	92.4±17.1	93.8±9.6
FEV_1 (l)	2.58±0.7	2.50±0.7	2.57±0.7
(% pred)	84.8±14.7	83.7±20.9	88.1±12.0
PEF (l/s)	6.26±2.1	6.02±2.0	6.42±2.3
(% pred)	79.5±22.2	76.7±22.6	82.8±24.6
FEV_1/FVC%	72.0±7.6	71.9±10.8	75.3±6.5
(% pred)	90.5±9.0	89.9±13.4	94.6±7.7
$FEF_{25-75\%}$ (l/s)	2.14±1.0	2.22±1.1	2.36±0.9
(% pred)	63.2±23.0	66.4±31.7	71.6±21.6
Operative data			
Total no. of grafts	2.35±1.0	2.38±1.0	2.48±1.2
Duration of cardiopulmonary bypass (min)	39.6±18.0	43.4±21.5	39.2±16.9
Duration of anaesthesia (min)	156.8±29.7	155.0±39.5	157.5±31.7
Time to extubation (h)	10.2±3.8	9.2±3.8	9.4±3.3
Post-operative data			
Total dosage omnopon (mg)	82.2±53.3	94.6±52.1	94.6±50.9
Additional antibiotics (n)	8	15	8
Length of post-operative stay (days)	9.0±5.7	10.4±6.9	8.5±2.6

[a] Values are means ± standard deviations unless otherwise stated.
Note: BMI, body mass index; FVC, forced vital capacity; % pred, percentage predicted normal value; FEV_1, forced expiratory volume in 1 sec; PEF, peak expiratory flow; $FEF_{25-75\%}$, forced expiratory flow between 25 and 75% of FVC.

operative values ($P<0.001$), with a mean 75.6± 18.7%. There were no significant differences between groups in any blood gas data at any stage.

Considering the mean total chest x-ray scores, nine patients had evidence of minor atelectasis pre-operatively (a score of 0 was recorded for the other 111 pre-operative films). On days 1 and 4, the mean total scores reflected the presence of atelectasis of minimal to moderate severity. Most atelectases were located in the lower lobes and the mean scores for the right lower lobe and left lower lobe are given in Table 2. There were no significant differences between groups in the chest x-ray scores. The incidence and location of atelectasis on days 1 and 4 are shown in Fig. 1. There were insufficient numbers in some categories to enable statistical analysis. However, the number of patients in categories differed minimally, even in the more commonly occurring categories, suggesting little difference between groups in the incidence or the location of the abnormalities pre- or post-operatively. Pleural effusions were noted in 33 patients (27.5%) on the first post-operative day and in 95 patients (80.5%) on the fourth post-operative day. On day

Table 2
Oral temperatures, arterial blood gas analyses and chest x-ray scores[a]

	Group 1	Group 2	Group 3
Pre-operative			
Temperature (°C)	36.4 ± 0.4	36.6 ± 0.5	36.5 ± 0.4
Arterial blood gases			
paO_2 (mmHg)	83.8 ± 10.5	84.2 ± 9.9	82.9 ± 10.5
$paCO_2$ (mmHg)	39.4 ± 3.4	39.1 ± 3.7	39.9 ± 2.9
pH	7.41 ± 0.02	7.42 ± 0.03	7.41 ± 0.02
Chest x-ray scores			
Total score	0.3	0.6	0
RLL score	0.15	0.15	0
LLL score	0.15	0.45	0
Post-operative: Day 1			
Temperature (°C)	37.5 ± 0.6	37.6 ± 0.4	37.5 ± 0.6
Temperature (≥38°C) (*n*)	12	11	8
Arterial blood gases			
paO_2 (mmHg)	125.4 ± 40.1	125.0 ± 46.5	141.2 ± 53.4
$paCO_2$ (mmHg)	46.6 ± 7.3	46.2 ± 4.6	48.3 ± 5.2
pH	7.35 ± 0.05	7.35 ± 0.04	7.33 ± 0.04
paO_2/FiO_2 % pre-op.	50.7 ± 18.5	48.0 ± 18.7	54.8 ± 18.2
Chest x-ray scores			
Total score	4.5 ± 0.5	5.3 ± 0.5	5.2 ± 0.5
RLL score	1.5 ± 0.3	1.7 ± 0.3	1.3 ± 0.3
LLL score	2.9 ± 0.4	3.5 ± 0.4	3.9 ± 0.4
Post-operative: Day 4			
Temperature (°C)	37.3 ± 0.6	37.2 ± 0.5	37.0 ± 0.6
Temperature (≥38°C) (*n*)	4	1	1
Arterial blood gases			
paO_2 (mmHg)	68.7 ± 14.1	67.7 ± 12.8	69.5 ± 14.7
$paCO_2$ (mmHg)	38.1 ± 6.1	37.2 ± 3.4	37.6 ± 3.9
pH	7.44 ± 0.04	7.45 ± 0.03	7.44 ± 0.04
paO_2/FiO_2 % pre-op.	77.0 ± 19.8	74.4 ± 16.1	75.5 ± 20.1
Chest x-ray scores			
Total score	4.9 ± 0.5	5.5 ± 0.5	6.6 ± 0.5
RLL score	1.7 ± 0.3	1.3 ± 0.3	2.0 ± 0.3
LLL score	3.2 ± 0.5	4.2 ± 0.4	4.6 ± 0.4

[a] Values for temperature and arterial blood gases are means ± standard deviations. Values for temperature ≥38°C are numbers of patients. Values for chest x-ray scores are means ± standard errors. Standard errors are not given for pre-operative values because of too few patients with scores greater than 0.

The number in each group for oral temperatures was 40 at all times. The number in each group for arterial blood gas analyses pre-operatively and on days 1 and 4 was: group 1, 39, 39 and 39; group 2, 37, 38 and 38; group 3, 39, 39 and 39. For chest x-ray scores the number in each group pre-operatively and on days 1 and 4 was: group 1, 40, 40 and 38; group 2, 40, 40 and 40; group 3, 40, 40 and 39.

Note: paO_2, partial pressure of oxygen in arterial blood; $paCO_2$, partial pressure of carbon dioxide in arterial blood; paO_2/FiO_2 % pre-op., paO_2/inspired fraction of oxygen as a percentage of the pre-operative value; RLL, right lower lobe; LLL, left lower lobe.

l most of the effusions were small and left-sided, whereas on day 4 small bilateral effusions were most common.

The cardiologist identified nine patients (7.5%) as having clinically significant pulmonary complications. Table 3 summarises the data from these nine patients. Three patients developed the complications within 12 h of completion of surgery before chest physiotherapy was scheduled to commence. This indicates that the complications could not be attributed to the presence or absence of prophylactic chest physiotherapy. The other six patients were diagnosed as having sputum retention and/or chest infection from

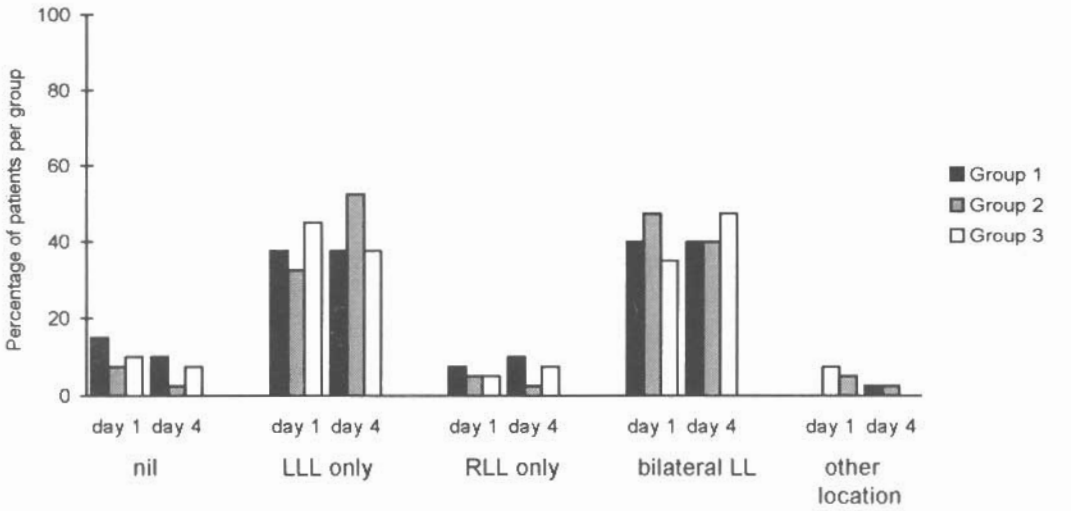

Fig. 1 Incidence and location of atelectasis on the first and fourth post-operative days. LLL, left lower lobe; RLL, right lower lobe; LL, lower lobes.

late on day 1 to day 3, a time when it could be anticipated that the presence or absence of chest physiotherapy may have been a related factor. The low incidence of pulmonary complications overall does not allow statistical analysis; however, the incidence of these complications was similar between groups, with one patient in group 1, four patients in group 2 and one patient in group 3 being affected.

Of these nine patients, five also developed left ventricular failure (LVF). Four of these five patients developed LVF subsequent to, or perhaps as a result of, the pulmonary complication, with evidence of respiratory disease present initially (sputum retention and chest infection). The other patient had severe pulmonary dysfunction but there was no evidence of respiratory disease and it became apparent retrospectively that the primary problem was LVF.

The nine patients with clinically significant pulmonary complications required medical treatment over and above the standard care given for routine coronary artery surgery patients. Similarly, these patients required intensive chest physiotherapy over a period of days, although continuing intensive chest physiotherapy was not required for the patient with primary LVF once the correct diagnosis was established. The mean ($\pm$SD) length of post-operative stay of these patients was significantly prolonged to 15.1 ± 1.7 days, compared with 8.8 ± 0.5 days for those patients without pulmonary complications ($P<0.0005$). Compared with the patients without clinically significant pulmonary complications, the nine patients with these complications showed significantly lower values for some pre-operative pulmonary function tests and levels of oxygenation in the early post-operative period. Table 4 gives the data which were significantly different (or approaching significance) between the nine patients with pulmonary complications and those without complications. All other pulmonary function data, pre-operative profiles and operative data were not significantly different between patients with or without pulmonary complications.

DISCUSSION

This study showed that the incidence and severity of hypoxaemia, fever, chest x-ray abnormalities and clinically significant pulmonary complications were not significantly higher for a control group where patients did not receive pre- or post-operative chest physiotherapy compared with treatment groups which received prophylactic breathing and coughing exercises post-operatively. The frequency and extent of these findings were similar to those reported previously (Gale and Sanders, 1980; Stock et al, 1984; Rau

Table 3
Data for the nine patients with clinically significant pulmonary complications

Gender/ age (years)	Pack years	Group	Day of diagnosis	Initial diagnostic signs	Diagnosis	Medical management	Length of post-operative stay (days)
M/60	70	1	0–1	Confused, drowsy, appearance, auscultation, ↑ RR, ↑ HR, ↓ SaO_2	Acute respiratory failure, sputum retention	IPPV, inotropes, antibiotics, bronchodilators	28
M/71	7	3	0–1	Appearance, auscultation, ↑ RR, ↑ JVP, ↓ SaO_2	Acute respiratory failure, LVF	O_2, CPAP, inotropes, diuretics, bronchodilators	8
F/78	25	3	0–1	Confused, auscultation, ↑ JVP, ↓ SaO_2	LVF	O_2, diuretics	9
M/53	40	2	1	Appearance, auscultation, ↑ RR, ↑ HR, ↓ SaO_2	Sputum retention, chest infection	IPPV, antibiotics, bronchodilators	15
M/51	30	1	2	Appearance, auscultation, fever, ↑ RR, ↑ HR, ↓ SaO_2	Sputum retention, chest infection, LVF	IPPV, antibiotics, bronchodilators, inotropes, diuretics	34
M/52	23	2	2	Appearance, auscultation, fever, ↑ RR, ↑ HR, ↓ SaO_2	Sputum retention, chest infection, AF, LVF	O_2, antibiotics bronchodilators, diuretics, antiarrhythmics	10
M/51	60	2	2	Appearance auscultation, fever, ↑ RR, ↑ HR, ↓ SaO_2	Chest infection	O_2, antibiotics, bronchodilators	14
M/54	0	3	2	Appearance auscultation, fever, ↑ RR, ↓ SaO_2	Chest infection	O_2, antibiotics, bronchodilators	9
M/68	60	2	3	Appearance, auscultation, fever, ↑ RR, ↑ HR, ↓ SaO_2	Sputum retention, chest infection, LVF	O_2, antibiotics, bronchodilators, diuretics	9

Note: RR, respiratory rate; HR, heart rate; SaO_2, saturation of oxygen; JVP, jugular venous pressure; LVF, left ventricular failure; AF, atrial fibrillation; IPPV, intermittent positive pressure ventilation; CPAP, continuous positive airway pressure.

et al, 1988; Jenkins et al, 1989; Pinilla et al, 1990; Jain et al, 1991; Oikkonen et al, 1991; Singh et al, 1992).

For most of the patients in the present study, the abnormalities of temperature, arterial blood gas values and chest x-ray findings found on days 1 and 4 post-operatively were not accompanied by any observable manifestations of illness, nor was any specific medical intervention required for their treatment. Conversely, the patients identified as having clinically significant pulmonary complications demonstrated obvious signs of marked pulmonary dysfunction and signs of respiratory distress. The extent and type of treatment required for these patients and their extended length of post-operative stay confirms

Table 4
Data which were significantly different (or approaching significance) between the nine patients with clinically significant pulmonary complications and those patients without complications*

	Patients with complications ($n=9$)	Patients without complications ($n=111$)	Statistical test	*P*-value
Pack years	35.0±8.2	18.3±2.3	*t*-test	0.05
Pulmonary function				
FVC (% pred)	83.2±4.3	93.8±1.2	*t*-test	0.02
FEV_1 (% pred)	76.0±5.4	86.3±1.5	*t*-test	0.07
PEF (l/s)	4.84±0.7	6.35±0.2	*t*-test	0.04
PEF (% pred)	60.6±7.5	81.2±2.1	*t*-test	0.01
Day 1				
paO_2 (mmHg)	86.1±15.2	134.5±4.5	*t*-test	0.003
paO_2/FiO_2 % pre-op.	35.1±6.4	52.5±1.8	*t*-test	0.01

*Values are means±standard errors.
Note: FVC, forced vital capacity; % pred, percentage predicted normal value; FEV_1, forced expiratory volume in 1 sec; PEF, peak expiratory flow; paO_2, partial pressure of oxygen in arterial blood; paO_2/FiO_2 % pre-op., paO_2/inspired fraction of oxygen as a percentage of the pre-operative value.

the clinical significance of the pulmonary complications diagnosed in this study. In many previous studies, the clinical importance of post-operative pulmonary complications has been poorly addressed and it is likely that in many instances these complications were clinically insignificant, self-limiting and may have resolved spontaneously (O'Donohue, 1992; Stiller and Munday, 1992).

The patients studied were typical of those who undergo coronary artery surgery in terms of their gender, age and positive smoking history. No attempt was made to select patients considered to be at low risk of developing complications. Thus it would seem unlikely that the study population was composed of an overall healthier sample of patients with less pre-operative risk factors. As there were no significant differences between groups in their pre-operative profiles or pulmonary function, it is unlikely that the control group was comprised of the healthier patients. Similarly, as the operative data were comparable between groups, this is unlikely to have affected the results.

As a consequence of giving informed consent prior to participation in the study, all the patients were made aware of the rationale for performing breathing and coughing exercises post-operatively. It is possible that this may have acted as a confounding variable; in particular, it may have affected the behaviour of the patients in the control group. Similarly, the brief reference to chest physiotherapy on the pre-operative video may also have sensitised patients to the perceived benefits of post-operative chest physiotherapy. For ethical reasons, this knowledge could not be withheld. It could be hypothesised that the shoulder girdle exercises performed by all patients participating in the study may have altered pulmonary function and thus have affected the incidence of pulmonary complications. However, any such effect should have been similar across groups. It was felt that these exercises could not be withheld from patients participating in the study without a separate study where shoulder girdle mobility was the dependent variable.

The decrements in pulmonary function which occur after coronary artery surgery are as severe, if not worse, than those which occur after upper abdominal surgery. Hence, it could be anticipated that the incidence of pulmonary complications in control groups would be similar. In two controlled studies of patients after upper abdominal surgery, the incidence of post-operative pulmonary complications was 88 and 60% in the control groups compared with approximately 33 and 19%, respectively, for those groups where patients received prophylactic chest physiotherapy (Celli, Rodriguez and Snider, 1984; Roukema, Carol and Prins, 1988). Thus it would seem that factors unique to upper abdominal surgery, such as the severity of pain, the incisional site, diaphragmatic

inhibition and cough suppression, may predispose these patients to a higher incidence of pulmonary complications than the coronary artery surgery population and hence be more responsive to treatment.

The results of this study suggest that the role of the physiotherapist in the respiratory management of patients after routine coronary artery surgery should be reviewed. Physiotherapists should continue to assess all patients daily for approximately 4 days post-operatively to detect the presence of clinically significant pulmonary complications and perform chest physiotherapy only with these patients. It is recommended that institutions in which all patients receive prophylactic chest physiotherapy after routine coronary artery surgery should review the necessity for such treatment. No attempt was made in this study to investigate the effectiveness of chest physiotherapy in the treatment of pulmonary complications once they occurred, nor was the role of physiotherapy in rehabilitation examined.

Acknowledgements

The authors would like to thank D. Craddock and J. Stubberfield, Cardiothoracic Surgeons, the patients, the medical and nursing staff of the Cardiothoracic Surgical Unit and members of the Department of Physiotherapy, Royal Adelaide Hospital, for their cooperation. We also acknowledge Naomi Haensel, Department of Physiotherapy, for her assistance.

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