Physiotherapy following cardiac surgery: Is it necessary during the intubation period?

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This randomised controlled clinical trial investigated whether physiotherapy during the period of mechanical ventilation following cardiac surgery influenced subject outcomes. Two hundred and thirty-six subjects admitted to the intensive care unit (ICU) following elective or semi-urgent cardiac surgery were randomised to either a treatment group, which received physiotherapy during the intubated phase, or a control group where physiotherapy was commenced only once the subject was extubated. No significant differences between the two groups were detected for length of intubation period, length of ICU stay, length of hospital stay, maximal daily incentive spirometry values or the incidence of post-operative pulmonary complications. For individuals following routine uncomplicated cardiac surgery, the provision of physiotherapy interventions during the post-operative intubation period does not improve outcomes. **[Patman S, Sanderson D and Blackmore M (2001): Physiotherapy following cardiac surgery: Is it necessary during the intubation period? *Australian Journal of Physiotherapy* 47: 7-16]**

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Introduction

Impairment of pulmonary function is one of the most significant post-operative complications following cardiac surgery (Vargas et al 1992). Historically, physiotherapy has been widely used in an attempt to improve post-operative pulmonary function. Whilst the effects of cardiac surgery on the respiratory system are well documented and essentially consist of reduction in lung volumes and arterial hypoxemia (Berrizbeita et al 1989, Estenne et al 1985, Gale et al 1979, Jenkins et al 1989a, Singh et al 1992, Taggart et al 1993, van Belle et al 1992), a number of authors have questioned the clinical significance of reported post-operative pulmonary changes following cardiac surgery and whether routine physiotherapy interventions should be provided (Bourn and Jenkins 1992, de Charmoy and Eales 1997, Jenkins et al 1989b, Jenkins et al 1990, Jenkins et al 1994, Johnson et al 1996, Rau et al 1988, Stiller et al 1994a, Stiller et al 1994b, Stiller et al 1995).

Recently, changes to the post-operative care of cardiac surgery patients have been advocated. Dunstan and Riddle (1997) reported that patients could be managed using "rapid recovery guidelines" without compromising patient outcomes or levels of satisfaction. Reyes et al (1997) reported that early extubation (7-11 hours post-operatively) following cardiac surgery resulted in a decrease in length of intensive care unit (ICU) stay and no increase in clinically important post-operative complications. Stafford et al (1997) reported that the introduction of a "fast-track regime" (using shorter acting anaesthesia, less reduction in intra-operative body core temperature and defined clinical milestones) for patients following coronary artery surgery did not increase the incidence of post-operative pulmonary complications.

Despite advances in peri-operative management of cardiac surgery patients and many authors questioning the efficacy of physiotherapy interventions, Tucker et al (1996) reported, in a survey of Australian and New Zealand hospitals in which cardiac surgery was performed, that 63% of hospitals still had a specific respiratory management protocol for intubated patients. Of these, 50% had physiotherapists performing suctioning and 36% had physiotherapists utilising the technique of manual hyperinflation. These findings suggest that physiotherapy in the intubated phase following cardiac surgery in Australia and New Zealand, whilst not universally administered, is still prevalent.

No study was identified that specifically addressed the effects of provision of physiotherapy interventions during the intubation period following cardiac

surgery. Therefore the aim of this study was to investigate outcome measures of two groups of subjects following cardiac surgery. One group received physiotherapy during the period of mechanical ventilation and the other group did not commence physiotherapy until after extubation.

Methods

The Ethics Committee of Royal Perth Hospital (RPH) granted approval for this randomised, controlled clinical trial, with the requirement for subject consent for inclusion being waived.

Subjects Two hundred and thirty-six subjects admitted consecutively to the surgical ICU of a major tertiary hospital (RPH) following elective or semi-urgent cardiac surgery were randomised to either receive physiotherapy interventions during the intubation period (treatment group), or receive physiotherapy interventions only after extubation had occurred (control group). Randomisation was performed by an independent person, with the use of a random numbers table (Portney and Watkins 1993). Using formulae for sample size determination (Portney and Watkins 1993) with a desired statistical power of 0.9, a medium effect size (d = 0.50) and an alpha of 0.05, it was calculated that a minimum sample size of 85 subjects for each group was necessary to establish statistical significance.

Exclusion criteria Any subject whose past medical history included conditions that may have influenced the provision of physiotherapy interventions such as severe asthma, chronic airflow limitation, bronchiectasis or ankylosing spondylitis was excluded.

Post-operatively, any subject who had unstable cardiovascular status (systolic blood pressure < 100 or > 180mmHg or mean arterial pressure < 60 or > 110mmHg), arrhythmias that compromised cardiovascular function, or excessive blood loss from subcostal catheters (> 100mL/hr) was excluded. Similarly any patient who suffered a peri-operative neurological complication was excluded.

Subjects for whom prolonged ventilatory support was required (> 24 hours) were withdrawn, as these subjects were no longer considered to be requiring routine post-operative care. These subjects had been randomised to groups and therefore were included in the analysis on the basis of intention to treat.

Independent variables The level of physiotherapy intervention (that is, whether the subject received physiotherapy treatment during the intubated phase of their post-operative recovery) was the sole independent variable during the testing period. The type of physiotherapy treatment was not standardised or controlled, as each subject may have had differing assessment findings requiring differing interventions. As a matter of course, the number of physiotherapy treatments provided to each subject was recorded.

Dependent variables The length of intubation period (from admission to ICU to extubation, in hours), length of ICU stay (hours), length of post-operative hospital stay (days), and the incidence of post-operative pulmonary complications were the dependent variables. Criteria used to define post-operative pulmonary complications included the presence of four or more of the following: oral temperature greater than 38 degrees Celsius, hypoxia with arterial oxygenation via pulse oximetry of less than 92% on room air; abnormal radiological findings on chest x-ray as reported by blinded experienced senior radiologists; altered white cell count (less than two or greater than $10x10^9$ cells per litre) on a full blood count sample, and positive sputum culture via microscopy. Daily recordings were also made of maximal incentive spirometry values obtained.

Procedure All subjects returning to the ICU following elective or semi-urgent cardiac surgery were assessed for inclusion in the study. Once inclusion criteria were established, subject randomisation was undertaken. Subjects randomised to the treatment group received physiotherapy interventions as required during the intubated phase of their post-operative course. Physiotherapy interventions were not specifically standardised or controlled for during the study. The physiotherapy services were provided by a core group of physiotherapists under the direct jurisdiction and supervision of the principal investigator to minimise, as much as clinically possible, any concerns of group by physiotherapist interactions. Techniques commonly used as part of physiotherapy interventions during the intubated phase of those in the treatment group included positioning, manual hyperinflation, endotracheal suctioning, thoracic expansion exercises and upper limb exercises.

Subjects randomised to the control group received no physiotherapy interventions during the intubation period. Once subjects were extubated there were no specific differences in physiotherapy management between those in either group. Incentive spirometry was only performed post extubation for all subjects.

Nursing procedures were not altered by patient inclusion to this study. At RPH, intubated patients following cardiac surgery are nursed initially in a supine posture and then semi-erect as cardiovascular status allows and as conscious state improves following recovery from anaesthesia. Nursing staff, (generally in response to patient coughing), intermittently performed endotracheal suctioning only and did not use manual hyperinflation as part of their standard suctioning procedure. A clinical pathway for cardiac surgery patients in ICU at RPH was in use during this study. Variables such as minimum ventilation times or length of ICU stay are not dictated by clinical pathways but rather, decided on clinical status. Nursing and medical staff were blind to group allocation.

Measurement of the dependent variables was performed on a daily basis by the principal investigator and recorded on a standardised data collection form. The principal investigator was not blinded to the group allocation. The number of physiotherapy treatments provided to those in the treatment group whilst intubated was also recorded. The subject's status was reviewed daily to establish the presence of a post-operative pulmonary complication, as described above. Data collection of the dependent variables ceased once the subject had been discharged from RPH.

Data collection occurred for 52 weeks during the period from May 26, 1998 to May 21, 1999. A total of 236 subjects satisfied the inclusion criteria, representing approximately 93% of all elective and semi-urgent cardiac surgery cases returning to the ICU post-operatively. This sample exceeded the predicted minimum sample size required from advance power calculations, even allowing for 15% withdrawals; data collection was continued for the 52 week period to further enhance the power of the study.

After data collection, but before conducting the following analyses, three variables were selected as possible predictors of response to treatment. These were smoking history, body mass index (BMI), and cardiopulmonary bypass time (CPB). Smoking history was selected because smoking is believed to increase the risk of post-operative pulmonary complications by virtue of its adverse effects on the respiratory and cardiovascular systems, and Jenkins et al (1989b) and Warner et al (1989) both reported in their studies of extubated subjects following cardiac surgery a higher incidence of post-operative pulmonary complications in current or recently ceased smokers. The BMI was selected because it is thought that pulmonary function may be adversely affected in obese subjects due to mechanical properties of the chest wall being interfered with by increased abdominal size and therefore predisposing obese subjects to a higher incidence of post-operative pulmonary complications (Jenkins and Moxham 1991). However, specific studies investigating the effects of obesity on post-operative pulmonary complications following cardiac surgery were not identified. The CPB was selected because it is believed to increase the risk of infection (Bourn and Jenkins 1992, Van Oeveren and Wildevuur 1987, Westaby 1983), but the association between CPB and post-operative pulmonary complications following cardiac surgery has not been clearly established.

Statistical analysis Data analysis was performed using the SPSS® Base 9.0 for Windows™ statistical package. Chi square tests and *t*-tests for independent samples were used to investigate the success of the randomisation process in achieving two comparable groups. A MANOVA was conducted to determine whether the two groups differed on the three dependent variables: length of intubation, length of ICU stay or length of hospital stay. The risk factors, history of smoking, CPB and BMI were also investigated to see whether they predicted response to treatment. This was done by investigating the interaction effects between the risk factors and group in ANOVA and multiple regression.

Levene's test was performed to determine if equality of variances between the groups existed, and measures of skewness and kurtosis were obtained to investigate the normality of the data. The ratio of the test statistic to its standard error was used as a test of normality, with normality rejected if the ratio was less than negative two or greater than two (SPSS Inc 1999, p. 28). Dependent variables that clearly were not normally distributed were transformed with an inverse transformation before the analysis was conducted. The primary analysis performed on the dependent variables was a one-way MANOVA, with

Table 1. Pre-operative data for the two groups and for the subjects withdrawn from each group.

Variable		Treatment Group (n = 101)	Withdrawn from Treatment Group (n = 7)	Control Group (n = 109)	Withdrawn from Control Group (n = 19)	p-value
Sex (male/female)	number	81/20	4/3	77/32	16/3	0.28
Age (years)	mean (SD) range	62.8 (12.2) 29 - 84	67.3 (18.6) 31 - 85	63.9 (14.4) 18 - 90	68.7 (9.4) 45 - 84	0.39
Body mass index (kg/m^2)	mean (SD) range	28.2 (5.4) 19.5 - 54.7	31.3 (7.3) 24.3 - 42.4	27.9 (4.6) 19.0 - 44.4	27.5 (2.6) 24.5 - 34.0	0.41
FEV_1 (L)	mean (SD) range	2.6 (0.7) 0.8 - 4.3	1.9 (0.6) 1.3 - 2.4	2.4 (0.8) 0.54 - 4.5	2.4 (0.6) 1.4 - 3.4	0.19
FEV_1 (% pred)	mean (SD) range	90.7 (21.2) 40.0 - 156.0	98.5 (28.3) 77.0 - 144.0	88.5 (21.2) 28.0 - 147.0	95.2 (19.1) 71.0 - 128.0	0.08
FVC (L)	mean (SD) range	3.3 (0.9) 1.2 - 5.3	2.4 (0.6) 1.7 - 3.0	3.1 (1.0) 0.7 - 5.3	3.0 (0.7) 1.7 - 4.0	0.13
FVC (% pred)	mean (SD) range	90.3 (21.9) 43.0 - 145.0	98.0 (24.8) 82.0 - 135.0	86.4 (23.6) 30.0 - 152.0	92.7 (17.8) 72.0 - 118.0	0.14
FEV_1 / FVC (%)	mean (SD) range	78.8 (10.4) 54.0 - 96.0	78.4 (4.8) 73.0 - 85.0	78.5 (7.4) 55.0 - 93.0	80.0 (6.0) 69.0 - 89.0	0.94
Respiratory past medical history *	nil asthma CAL other	87 (86) 7 (7) 2 (2) 5 (5)	4 (57) 1 (14) 1 (14) 1 (14)	94 (87) 7 (7) 2 (2) 6 (6)	15 (79) 1 (5) 1 (5) 2 (11)	0.98
Smoking history *	non-smoker current smoker ex-smoker > 6/52	31 (31) 46 (46) 24 (24)	3 (43) 1 (14) 3 (43)	39 (36) 14 (13) 56 (52)	6 (32) 1 (5) 12 (63)	0.10
Chronic sputum production *	yes	10 (10)	1 (14)	8 (3.4)	0 (0)	0.26
Left ventricular function (from pre-op angiography assessment)*	good moderate poor	49 (49) 46 (46) 6 (6)	2 (29) 3 (43) 2 (29)	63 (58.3) 36 (33.3) 10 (9.3)	7 (37) 6 (32) 5 (26)	0.13

* = values are numbers of subjects with percentages of total in parentheses
FEV_1 = forced expiratory volume in one second, L = litre; FVC = forced vital capacity; % pred = percentage of predicted normal value (Micro Medical 1994), CAL = chronic airflow limitation; p values refer to the contrasts between all four groups

alpha set at 0.05. Series of ANOVAs and multiple regressions on the data were then performed with the aim of identifying risk factors that may have influenced the outcomes of the dependent variables.

A one-way MANOVA was conducted to examine differences between the groups on the dependent variables. The assumptions of MANOVA were tested. The two cells of 101 and 109 were large and similar in size. Of the three dependent variables, length of intubation was normally distributed, but both length of ICU stay and length of post-operative hospital stay were severely positively skewed. Therefore, an inverse transformation was performed on the last two variables. After transformation, there were no multivariate outliers detected by Mahalanobis distance. Scatter plots showed linear relationships between all pairs of dependent variables. Assumptions of univariate homogeneity of variance (as tested by Levene's test) and multivariate homogeneity of variance-covariance matrices (as

Table 2. Operative and post-operative data for the 236 subjects according to allocated group.

Variable		Treatment Group (n = 108)	Withdrawn from Treatment Group (n = 7)	Control Group (n = 109)	Withdrawn from Control Group (n = 19)	p-value
Operation type *	CAS	71 (70)	4 (57)	68 (62)	17 (90)	
	AVR	9 (9)	1 (14)	14 (13)	0 (0)	
	MVR	7 (7)	0 (0)	17 (16)	0 (0)	0.29
	Bentall's	2 (2)	0 (0)	1 (1)	0 (0)	
	Other	12 (12)	2 (29)	9 (8)	1 (5)	
Mean number of grafts	mean (SD)	3.0 (1.0)	4.0 (1.0)	3.2 (1.1)	3.7 (1.1)	0.25
	range	1 - 5	3 - 5	1 - 6	2 - 5	
Conduit used *	LIMA ± SVG	64 (63)	4 (57)	60 (55)	14 (74)	
	SVG only	9 (9)	1 (14)	6 (6)	2 (11)	0.39
	IMA + radial artery	6 (6)	0 (0)	8 (8)	2 (11)	
	BIMA	4 (4)	0 (0)	1 (1)	0 (0)	
Cardiopulmonary bypass time (min)	mean (SD)	98.5 (42.8)	134.3 (69.4)	95.1 (37.9)	121.1 (60.1)	0.95
	range	0 - 271	67 - 271	0 - 209	0 - 263	
Aortic cross clamp time (min)	mean (SD)	60.4 (29.6)	82.9 (45.8)	58.3 (26.0)	56.2 (27.3)	0.52
	range	0 - 164	29 - 163	0 - 147	0 - 109	

* = values are numbers of subjects with percentages of total in parentheses
CAS = coronary artery surgery; AVR = aortic valve replacement; MVR = mitral valve replacement; other = combination procedure; LIMA = left internal mammary artery; SVG = saphenous vein graft; IMA = internal mammary artery; BIMA = bilateral internal mammary artery; p values refer to the contrast between all four groups

tested by Box's M test) were met, as were assumptions of no multicollinearity or singularity.

The first possible predictor variable, smoking history, was a categorical variable in three categories: (a) currently smoking or ceased smoking less than six weeks previously, (b) ceased smoking more than six weeks previously, and (c) never smoked. In order to determine whether the effectiveness of the treatment depended on smoking history, a three (smoking group) by two (study group) MANOVA was conducted with length of intubation, ICU stay and hospital stay as the dependent variables. In testing the assumptions, it became apparent that the cell sizes were very uneven, ranging from 14 to 56. Therefore, cases were randomly selected from the larger cells to produce six cells, each with exactly 14 cases. After this was done, the means of the new cells were compared with the means of the original cells to ensure that they were similar. The other assumptions were all tested in the same way as for the previous MANOVA.

The other two variables identified as possibly predicting response to treatment, BMI and CPB, were both continuous variables. Therefore multiple regression (instead of ANOVA) was used to examine their interactions with the variable, the study group, in predicting length of intubation, ICU stay and hospital stay. Pedhazur (1982) describes how multiple regression can be used to examine the interaction between a categorical variable (such as the treatment group) and a continuous variable (such as BMI and CPB) in predicting a dependent variable. This is done by entering the categorical and continuous variables into the regression in the first two steps, and the product of these two variables in the third step. The statistics of interest are the R^2 change and the corresponding p value associated with the third step (the interaction), because this indicates whether the interaction between the two independent variables accounts for a significant proportion of the variance in the dependent variable beyond that accounted for by each of the independent variables alone. This procedure was performed for each dependent variable (length of intubation, ICU stay and hospital stay), first

Table 3. Group differences on the dependent variables: intubation, ICU stay and hospital stay.

Dependent variable	Treatment group (n = 101) Mean (SD)	Control group (n = 109) Mean (SD)	Difference between means	95% confidence interval	$F_{(1,208)}$	p-value
Intubation (hours)	13.0 (4.8)	12.7 (4.7)	0.2	-1.1 to 1.65	0.03	0.85
ICU stay (hours)	42.7 (42.4)	36.7 (26.8)	6.0	-3.6 to 15.6	0.34	0.56
Hospital stay (days)	9.2 (4.5)	9.6 (6.7)	-0.4	-2.0 to 1.1	1.35	0 .25

n = number; SD = standard deviation; ICU = intensive care unit

with BMI and the intervention group as the independent variables, and then with CPB and the intervention group as the independent variables. This yielded the six regression analyses shown in Table 4.

The assumptions underlying multiple regression were tested. The ratio of cases to independent variables was far greater than required. Distributions of all variables were normal, though there were a few outliers on the independent variables. In view of the large sample size, these were not excluded from the sample for this analysis. However, one extreme multivariate outlier, detected by Mahalinobis distance, was excluded from the analysis. Assumptions of multicollinearity and singularity were met. Assumptions of normality, linearity, homoscedasticity and independence of residuals were tested by residual scatter plots.

Results

Of the 236 subjects, 210 completed the study (treatment group n = 101; control group n = 109). Seven subjects were withdrawn from the treatment group and 19 from the control group, with prolonged ventilation for more than 24 hours being the main reason for subject withdrawal. A Chi square analysis showed that this difference was significant, though only borderline, $\chi^2_{(1)} = 4.18$, $p = 0.04$. The relative risk of being withdrawn from the study for subjects in the control group (compared with the treatment group) was 2.29 (95% CI: 1.00 to 5.24).

Of the 26 withdrawn subjects, 18 subjects returned to theatre within the first 24 hours and subsequently had prolonged ventilation for greater than 24 hours or cardiovascular support requirements necessitating withdrawal from the study. A further three subjects died in ICU and five subjects were slow to wake from anaesthesia and required ventilatory support for more than 24 hours.

Pre-operative data are provided in Table 1, whilst operative and post-operative data are provided in Table 2. An ANOVA comparing the four groups (treatment, control, and subjects withdrawn from treatment and control) found no significant differences. Following Chi square and t-tests on demographic and operative data, it was concluded that the subjects remaining in the two groups were not significantly different. Similarly, no significant differences between groups for the withdrawn subjects for demographic data, operative details or dependent variables were found. The mean number of physiotherapy interventions provided to subjects of the treatment group was 1.84 (SD = 0.95, range = 1-6).

A one-way MANOVA was performed on these data with group as the independent variable and length of intubation, length of ICU stay and length of post-operative hospital stay as the dependent variables. There was no significant difference between the groups on the multivariate F-test ($F_{(3,206)} = 0.20$, $p = 0.90$). Table 3 shows the means and standard deviations of length of intubation, ICU stay and hospital stay for each group. On average, patients in the treatment group spent only 15 minutes longer on intubation, six hours longer in the ICU, and 0.4 days less in hospital than patients in the control group. The 95% confidence intervals for the differences between the means are also shown. Univariate results from the MANOVA shown in Table 3 indicate no significant differences on any of the dependent variables.

Table 4. Multiple regression analyses of BMI with the study group, and CPB with the study group, on the dependent variables: intubation, ICU stay and hospital stay.

	BMI and Group					CPB and Group			
	Step	df	R^2 change	*F* change	*p*	Step	R^2 change	*F* change	*p*
Intubation	1. group	1, 207	0.001	0.15	0.698	1. group	0.001	0.15	0.698
	2. BMI	1, 206	0.001	0.11	0.747	2. CPB	0.043	9.29	0.003
	3. interaction	1, 205	0.000	0.00	0.991	3. interaction	0.001	0.12	0.735
ICU Stay	1. group	1, 207	0.004	0.80	0.374	1. group	0.004	0.80	0.374
	2. BMI	1, 206	0.012	2.56	0.111	2. CPB	0.038	8.18	0.005
	3. interaction	1, 205	0.013	2.69	0.103	3. interaction	0.003	0.74	0.392
Hospital Stay	1. group	1, 207	0.000	0.07	0.789	1. group	0.000	0.07	0.79
	2. BMI	1, 206	0.010	2.00	0.159	2. CPB	0.149	36.08	> 0.001
	3. interaction	1, 205	0.000	0.07	0.789	3. interaction	0.002	0.40	0.528

BMI = body mass index; CPB = cardiopulmonary bypass time; ICU = intensive care unit

With the MANOVA exploring whether the effectiveness of the treatment depended on smoking history, the multivariate *F* value for the interaction was not significant ($F_{(6,154)}$ = 0.72, p = 0.64). Therefore, there was no evidence that smoking history influenced response to treatment. As for the main effects, there was no difference between the groups ($F_{(3,76)}$ = 0.39, p = 0.76). However, the effect for smoking history was nearly significant ($F_{(6,154)}$ = 2.18, p = 0.05). Univariate test results showed that this was due to a difference among the groups on length of intubation ($F_{(2,78)}$ = 4.90, p = 0.01) but not length of ICU stay ($F_{(2,78)}$ = 2.72, p = 0.07) or length of hospital stay ($F_{(2,78)}$ = 0.09, p = 0.92). Scheffe's tests showed that the current and recent smokers spent significantly less time on intubation (mean = 10.4 hours, SD = 3.4) than the group that stopped smoking more than six weeks previously (mean = 13.5, SD = 5.2, p = 0.05) and than those who had never smoked (mean = 13.9, SD = 4.7, p = 0.02), but there was no significant difference between the groups of smokers and previous smokers (p = 0.94).

The results of the regression are shown in Table 4. None of the interaction effects were significant, indicating that there is no evidence that patients respond differently to treatment depending on their BMI or their CPB. The only significant effects observed were main effects for CPB on all three dependent variables. The longer that patients were on CPB, the longer they remained on ventilation, in ICU, and in hospital.

No significant differences were found via *t*-tests between the groups for daily maximal incentive spirometry values up to seven days post-operatively. Five patients in the treatment group (n = 101) and five in the control group (n = 109) developed post-operative pulmonary complications. On this evidence, the risk of developing complications appears to be similar in the two groups, but the numbers are too small for any formal analysis of these data.

Discussion

There are many aspects of cardiac surgery that may have an adverse effect on pulmonary function. The specific mechanisms of peri-operative physiological alterations in lung function are well described (Fairshter and Williams 1987, Foltz and Benumof 1987, Jones et al 1990, Marini 1984, Warner and Rehder 1995). Historically, techniques such as positioning, manual hyperinflation, chest wall vibrations and endotracheal suctioning may have been instigated by physiotherapists with the aim of assisting with bronchial secretion removal and improving ventilation-perfusion matching following cardiac surgery.

By minimising pathophysiological abnormalities affecting the respiratory and cardiovascular system through the provision of physiotherapy interventions, it was thought that post-operative pulmonary complications might be prevented. However, it has

been established that the addition of breathing exercises or incentive spirometry to a regimen of early mobilisation and huffing and coughing is of no extra benefit following uncomplicated coronary artery surgery (Crowe and Bradley 1997, Dull and Dull 1983, Jenkins et al 1989b, Jenkins et al 1990, Johnson et al 1995, Johnson et al 1996).

The findings of de Charmoy and Eales (1997), Stiller et al (1994a), Stiller et al (1994b), and Stiller et al (1995) suggest that prophylactic chest physiotherapy is not required after routine cardiac surgery, as it does not influence the incidence of clinically significant pulmonary complications. However, no study was identified in which the effect of physiotherapy interventions during the intubation period following cardiac surgery on clinical outcomes was examined. A few authors have investigated the response of physiological parameters (such as arterial oxygenation, lung compliance and cardiac output) to physiotherapy interventions in mechanically ventilated subjects following cardiac surgery (Eales et al 1995, Gormezano and Branthwaite 1972, Patman et al 1998, Rhodes 1987), but none of these authors explored whether changes in physiological variables altered clinical outcomes.

This study was the first to specifically examine the effects on post-operative pulmonary complications and other defined outcomes of provision of physiotherapy in the immediate post-operative period whilst the subject remained mechanically ventilated following cardiac surgery.

With the establishment that the treatment and control groups were not significantly different for demographic and operative data, the subsequent comparison between the two groups suggested that the provision of physiotherapy interventions during the post-operative intubation period does not improve outcomes. As subjects in the treatment group only received, on average, fewer than two physiotherapy interventions prior to extubation, it may be that the results obtained reflect that this intensity of treatment is not sufficient to influence pathophysiological abnormalities affecting the respiratory and cardiovascular system following cardiac surgery. It is not known if increasing the frequency and intensity with which physiotherapy interventions are provided prior to extubation following cardiac surgery is likely to be efficacious and improve clinical outcomes.

Interestingly, subjects included in this study are of a higher mean age than those of Jenkins et al (1989b) and Jenkins et al (1990), are more obese than those of Johnson et al (1996) and Stiller et al (1994a), Stiller et al (1994b) and Stiller et al (1995), and had a longer CPB and length of ventilation compared with Stiller et al (1994a), Stiller et al (1994b) and Stiller et al (1995) but much shorter than those of Johnson et al (1996). It is possible that with an older and more obese study population that underwent longer CPB and post-operative ventilation, one could expect a higher incidence of post-operative pulmonary complications, and for subject outcomes to be more responsive to the provision of early post-operative physiotherapy. However, no differences between the groups on any of chosen outcomes were found and the incidence of post-operative pulmonary complications in this study was only 5%, which is less than that reported previously (Jenkins et al 1989b, Jenkins et al 1994, Stiller et al 1994a and Stiller et al 1994b). It is worth noting that only elective and semi-urgent cardiac surgery subjects were included in this study; those requiring urgent or emergency surgery were excluded as in general they did not undergo a routine pre-operative workup and experienced more respiratory and cardiovascular system instability in the peri-operative period following cardiac surgery. It should also be noted that this study did not attempt to investigate the effectiveness of physiotherapy interventions in the treatment of any post-operative pulmonary complication that did occur.

Prior to making a blanket statement concluding that physiotherapy interventions are not beneficial during the post-operative intubation period following cardiac surgery, it was felt prudent to further explore whether certain sub-sections of the study population responded differently. Previous studies have attempted to identify (from pre-operative data) patients at risk of developing post-operative pulmonary complications. Dull and Dull (1983), Jenkins et al (1990) and Stiller et al (1994a) used characteristics such as smoking history, obesity, pulmonary function tests and respiratory past medical history to identify subjects at a higher risk for post-operative pulmonary complications developing following cardiac surgery. Therefore, in this study, an attempt was made to identify predictors influencing response to treatment, specifically looking at smoking history, BMI and CPB. It was observed that current and recent smokers spent less time intubated; this result was of borderline significance. There was an association between CPB and lengths of intubation

period, ICU stay and post-operative hospital stay but neither of these effects was influenced by the provision of physiotherapy intervention during the intubation period.

As in the present study, subjects requiring more than 24 hours of mechanical ventilation following cardiac surgery are not considered routine cases and have been withdrawn in previous studies (Jenkins et al 1990, Stiller et al 1994a). It is not known what the pre-operative characteristics of these subjects are, how this group of subjects respond to physiotherapy interventions, and whether they develop a higher rate of post-operative pulmonary complications.

The results from this study supplement the previous published studies investigating the provision of physiotherapy interventions during the extubated period and suggest that, in general, routine physiotherapy does not improve outcomes following uncomplicated cardiac surgery. However, it remains unclear from this study whether certain sub-sections of the cardiac surgery population are more likely to benefit from the provision of physiotherapy interventions during the post-operative intubation period or are more at risk of developing post-operative pulmonary complications.

Conclusions

No differences were found between treatment and control groups for the length of intubation period, length of ICU stay, length of post-operative hospital stay, incentive spirometry values and the incidence of post-operative pulmonary complications. Thus it was concluded that for routine, uncomplicated cardiac surgery subjects, the provision of physiotherapy interventions during the post-operative intubation period does not improve outcomes. Further research investigating risk factors for the development of post-operative pulmonary complications following cardiac surgery is required, to enable the physiotherapist to target their efforts and resources appropriately.

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