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The role of routine physiotherapy following open heart valve surgery in South Africans

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THE ROLE OF ROUTINE PHYSIOTHERAPY FOLLOWING OPEN HEART VALVE SURGERY IN SOUTH AFRICANS

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A research report submitted to the faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Science in Physiotherapy

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ABSTRACT

Post-operative physiotherapy for patients who have undergone uncomplicated coronary artery surgery has been shown to be of little value in preventing or restoring the abnormalities that occur in lung function, hypoxaemia, chest radiograph changes and length of post-operative hospital stay.

This study aimed to establish whether similar results would be found for a group of patients undergoing cardiac valve surgery who had an uncomplicated post-operative course. The relevance of using valve surgery patients is that a very large number of state health care patients undergo valve surgery due to the remaining high incidence of rheumatic heart disease in South Africa.

Thirty consecutive patients booked for elective valve surgery between June and September 1995 were included in the study once written informed consent had been obtained. The patients were then divided into two groups, a treatment group and a non-treatment group. The treatment group received a regimen of breathing exercises, coughing and mobilisation for the first four post-operative days while the non-treatment group were given a set of instructions to mobilise out of bed.

The two groups were well matched for age, height, weight, body mass index and intra-operative details. Post-operatively arterial blood gas values, chest x-rays, temperature and length of stay were assessed to determine if there was any benefit to a regime of physiotherapy. The data was analysed using non-parametrical statistical tests and the

chi-square test. The results of this study show that there is no benefit to a regime of physiotherapy in a group of patients who have undergone uncomplicated, elective valve surgery.

DECLARATION

I declare that this research report is my own unaided work, except to the extent indicated in the reference citations and acknowledgements. It is being submitted in partial fulfilment of the requirements for the degree of MSc (Physiotherapy) at the University of the Witwatersrand. It has not been submitted before for any other degree or examination in any other university.

Suzanne de Charmoy

29 day of May, 1998.

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LIST OF ABBREVIATIONS

BMI	Body mass index
^{o} C	degrees Celcius
^{o} F	degrees Fahrenheit
FIO_2	Fraction of inspired oxygen
PaO_2	Partial pressure of oxygen in earlobe capillary blood
$PaCO_2$	Partial pressure of carbon dioxide in earlobe capillary blood
PaO_2 / FIO_2	Ratio
$P(A-a)O_2$	Alveolar - arterial oxygen difference
NS	Not significant
NTR	Non-treatment group
TR	Treatment group
Sig	Significant

CHAPTER ONE

INTRODUCTION

Physiotherapists working in the cardiothoracic wards, spend a large proportion of time each day assessing and treating post-operative cardiac patients. In the last two decades, much research into different combinations of chest physiotherapy treatment techniques has occurred in an attempt to establish the most effective combination in preventing post-operative pulmonary complications. Recent research has compared specific chest physiotherapy regimes to a programme of walking the patients as soon as possible post-operatively (Jenkins et al, 1989; Jenkins et al, 1990; Stiller et al, 1994; Stiller et al, 1995). The research by Jenkins and Stiller has been largely confined to patients undergoing coronary artery bypass graft surgery. Patients who have had cardiac valvular surgery had not been researched as a separate group at the data collection stage of this project. It is thus difficult to determine whether the results from the Jenkins and Stiller studies would apply to this patient population.

A large number of patients in South Africa require some form of valvular surgery. This is principally a result of valvular damage due to rheumatic heart disease. Clinically rheumatic heart disease seems prevalent, however statistics of the overall current prevalence are not readily available. Although rheumatic heart disease is a chronic disease, it is not a chronic lifestyle disease, and thus the patients differ from those who require coronary artery surgery. The patient population included in this study is typical of that encountered in the State hospitals in Gauteng, South Africa. They do not have the risk factors associated with coronary artery disease, for example smoking, obesity and hypercholesterolaemia, which makes them a unique group to study. In the main, patients

with rheumatic valve disease, especially those presenting with active carditis, are young, black and have relatively underprivileged backgrounds (McClaren et al, 1975; Barlow, 1992a and 1992b; Marcus et al, 1994).

Since the first valve replacements in 1961, the operative procedures and the use of extracorporeal circulation, have been refined and improved upon. With the large numbers of patients seen with valvular heart disease requiring some form of operative intervention it is important to establish whether the results of the Jenkins and Stiller research are applicable to this patient population. It is also relevant to establish whether the need for routine post-operative physiotherapy exists in the light of the improvement in operative techniques and shortened anaesthetic times.

1.1 The aim of the study

The aims of this study were:

i. to evaluate the necessity of routine post-operative physiotherapy in a sample of patients who underwent uncomplicated valvular surgery.

ii to determine if the results obtained from patients undergoing coronary artery surgery were pertinent to patients undergoing valvular surgery.

In order to answer the research questions a study was designed to determine whether or not patients undergoing heart valvular surgery benefit from routine post-operative chest physiotherapy.

1.2 The research hypothesis

Routine post-operative physiotherapy, which includes a regimen of breathing exercises, coughing and walking, is of no benefit in the uncomplicated post-operative valvular surgery patient.

CHAPTER TWO

LITERATURE REVIEW

The relevant literature for this study was located with a CD ROM search on Medlars at the University of the Witwatersrand Medical Library, as well as a Medline search on the internet. The following keywords were used; physiotherapy, heart surgery, post-operative, breathing exercises and rheumatic heart disease. The articles identified from these searches were then limited to the English language publications only.

The topics covered in this review are important to the reasoning behind this study. Patients with valvular heart disease, particularly those caused by rheumatic heart disease, are no longer treated with such regularity in the first world. Thus little research in physiotherapy has been directed towards this particular group of patients. The reason for the decline in rheumatic heart disease in the first world is the appropriate treatment of streptococcal throat infections and an overall improvement in social conditions (MaClaren at al, 1975 and Barlow 1992a). In South Africa, the limited availability of health care practitioners, public transport and financial restraints result in non-treatment of streptococcal throat infections. A review of the pathophysiology, incidence and nature of rheumatic heart disease has been included in the literature review. Also included are the adverse effects of extracorporeal circulation. These sections are a summary of the literature and not a critique as I do not feel that I have the background to give a critique on valvular surgery. A critique of the physiotherapy literature involving post-operative cardiac patients will be included.

2.1 Rheumatic heart disease

Acute rheumatic fever is a self limiting inflammatory syndrome that sometimes follows Group A beta-haemolytic streptococcal infections of the throat. It typically tends to recur. It is characterised by carditis, polyarthritis, skin rashes, subcutaneous nodules and occasionally chorea. It leads to progressive damage of the endocardium, particularly the cardiac valves and their supporting structures resulting in either valvular stenosis or incompetence (Borman and Gotsman,1980).

Deformities of the heart valves as a result of rheumatic fever were first described by Morgagni in 1761 from autopsy dissection. However the clinical description of rheumatic heart disease was only described in 1886, some 120 years later (Borman and Gotsman, 1980).

The incidence of rheumatic heart disease has been on the decline in the developed world for many years. The decline is evident in the following statistics for the United States of America. In 1950 the death rate per 100 000 was 14, and in 1993 it was 1.7 (American heart association, 1997). The final mortality for 1993, as a result of rheumatic heart disease was 5 743, of which 1 790 (31%) was males and 3 953 (68.8%) were female. The reported prevalence from a study completed in India, which may be more comparable to the South African situation, was 6.4 per 1000 in the general rural population (Agarwal et al, 1995). In 1972 McLaren et al. conducted a survey of 12 050 Black school children in Soweto. They found an overall prevalence rate of 6.9 per 1000 with a peak rate of 19.2 per 1000 in children aged 15 to 18 years (McLaren et al, 1975).

Agarwal et al., (1995) reported that the prevalence increased with age until the age of 25 years. They also found that socio-economic class had a direct impact on the occurrence of rheumatic heart disease. Communal living and overcrowding are thought to increase the incidence because close personal contact facilitates the spread of streptococcal infections. This is put forward as one of the theories to explain the remaining high incidence of the disease in the third world. Other contributing factors to the continual spread of the Streptococcal infection include a poor understanding of the consequences of the disease, and the unavailability of accessible medical services and medicines. There remains, however, a factor, or factors, relating to socio-economic living conditions that are incompletely understood (Barlow, 1992a and 1992b; Marcus et al, 1994; Kaplan and Markowitz, 1988).

One to three weeks after the streptococcal infection a pancarditis develops. The involvement of the valves is seen as a series of grey warty vegetations along the edges of the valve cusps. These vegetations then fuse to form a rough ridge along the cusp margin. The mitral valve is affected in 85% of the cases and the aortic valve in 50%. Within ten years of the acute disease 50% of the cases develop into chronic rheumatic disease with a further 15% developing the chronic disease after the ten year period. The vegetations result in the formation of adhesions between the valve cusps leading to valvular stenosis (Borman and Gotsman,1980).

In a retrospective study by Marcus et al. (1994), 748 patients who had had haemodynamically severe rheumatic mitral valve disease requiring mitral valve surgery

were studied. Their results revealed that in one third of the patients, pure mitral regurgitation was the lesion. These patients had a mean age of 19 ± 11 years. This is in contrast to the findings in developed countries where haemodynamically severe rheumatic mitral valve disease generally presents in or after the fourth decade as mitral stenosis, with or without regurgitation. Moreover, the South African studies have shown that the mitral valve annulus is the initial abnormality caused by the active rheumatic process and that the severe mitral regurgitation results from secondary prolapse of the anterior mitral leaflet (Barlow et al, 1987, Barlow, 1992a; Marcus et al, 1994).

2.1.1 Physiology of valvular disease

A normal mitral valve measures 4.0 to 6.0 square centimetres in cross-sectional area. A significant narrowing of the valve area is required before symptoms appear. A valve orifice of 2.1 to 2.5 square centimetres will result in symptoms after extreme exertion. Moderate exertion will produce symptoms if the valve area is narrowed to 1.6 to 2.0 square centimetres. When the valve area is narrowed to 1.0 square centimetre normal daily activities will produce symptoms (Gorlin and Gorlin, 1951). At 1.0 square centimetre both the left atrial pressure and the pulmonary capillary wedge pressure are elevated, often above the level of oncotic pressure. With this degree of stenosis, a further increase in the pressure gradient across the mitral valve, in an attempt to increase forward flow, will result in pulmonary oedema.

The constant elevation of pulmonary capillary wedge pressure results in pulmonary vasoconstriction, which in time leads to structural changes in the pulmonary

arterioles and pulmonary artery hypertension. Should the cause of this not be corrected the end result is hypertrophy and eventual failure of the right ventricle. The chronic left atrial hypertension leads to left atrial enlargement and degenerative changes in the atrial wall that may result in atrial fibrillation (Gorlin and Gorlin, 1951).

2.1.2 Clinical features of valvular heart disease

The patients are commonly young females or males who complain of dyspnoea on exertion, fatigue or palpitations. Early on in the course of valvular disease evidence of pulmonary congestion is present, dyspnoea, orthopnoea and a persistent cough. Clinically the pulmonary hypertension described above may result in the patient feeling better. However the signs and symptoms of left-sided failure are replaced with those of right-sided failure namely, peripheral oedema and a raised jugular venous pressure (Austen and Hutter, 1981).

On physical examination, patients with long-standing low cardiac output may be thin, due to cardiac cachexia. They appear frail, and may also have signs of cyanosis in the lips, fingers and toes and a malar flush in the cheeks (Austen and Hutter, 1981).

2.1.3 A description of the patients undergoing valve surgery at the Johannesburg Hospital

In the year 1 June 1994 to 31 May 1995, 313 patients underwent cardiac valve surgery at the Johannesburg hospital. The patient population was composed of 239 Black, 27 White, 14 Asian and 33 Coloured individuals. Of these 182 were female and 131 were male. Seventy-six of these patients were under the age of 15. Two hundred and thirty-eight patients had mitral valve surgery and 123 had aortic valve surgery.

2.2 The effects of cardiopulmonary bypass

Since the first successful operation in which a patient was fully supported on cardiopulmonary bypass in 1953, many adverse effects have been identified. These include damage to the blood, in particular the platelets, altered composition and production of surfactant, and changes as a result of haemodilution.

2.2.1 Inflammatory process generated by the artificial surfaces of the extracorporeal circuit

The most important surfaces are probably those of the oxygenating area, where large amounts of blood are brought into direct contact with the oxygenating surface. This surface is either, gas in the bubble oxygenators, or a membrane in the

membrane oxygenators. The effect of platelet contact with a nonendothelial surface is as follows (Kirklin, 1993):

i) promotion of platelet aggregation which results in platelet emboli and a decrease in the platelet number and function post cardiopulmonary bypass.

ii) denaturation of carrier proteins ,with resultant breakdown of lipoproteins and generation of fat emboli.

iii) initiation of the humoral amplification system which mediates a whole body inflammatory response. The Hageman factor (factor XII) is activated immediately after the onset of cardiopulmonary bypass and this results in activation of the coagulation cascade and the kallikrein cascade amongst others. As a result of the coagulation cascade activation there is evidence of ongoing microcoagulation despite appropriate heperanisation. The kallikrein cascade results in the production of bradykinin which in turn has the following effects; increased vascular permeability, arteriole dilatation, initiation of smooth muscle contraction and it elicits pain. Bradykinin is metabolised mainly in the lungs, and so exclusion of the pulmonary circulation during cardiopulmonary bypass acts to sustain high circulating levels of bradykinin. These effects may contribute to the hypoxia and increased alveolar arterial difference noted in the post-operative patient. Physiotherapy is often requested as a means of improving post-operative arterial blood gas values.

2.2.2 Pulmonary changes related to haemodilution

The effects of haemodilution are due primarily to a decreased colloid osmotic pressure caused by the crystalloid priming solution used for extracorporeal bypass circuits, the colloid most affected is albumin (Webber and Garnett, 1973; Sanchez DeLeon et al.1982). In the studies done it has been difficult to determine the significance of a low colloid osmotic pressure due to the simultaneous microvascular injury incurred during cardiopulmonary bypass (Smith et al, 1987). A decreased capillary coloid osmotic pressure may cause a degree of interstitial oedema in the lungs. This may explain, in part, the increased incidence of atelectasis and ventilation - perfusion mismatching that occurs after extracorporeal support.

These factors added to the well known ones of hypoxia due to the lungs not being perfused, collapse of the lung during extracorporeal circulation, direct trauma from retraction of the lung and the effects of anaesthesia on the lungs combine to result in pulmonary insufficiency after open heart surgery (Howell and Hill, 1978; Bourn and Jenkins, 1992.).

The above findings present themselves clinically as an increased alveolar arterial oxygen difference ($P(A\text{-}a)O_2$), a reduced arterial oxygen tension (PaO_2), decreased oxygen saturation and an increased intrapulmonary shunt (PaO_2 / FIO_2) (West, 1990).

2.3 Chest physiotherapy techniques

In a study done by Varciu and Varciu (1977), a sample of forty patients undergoing open heart surgery was divided into a high risk and low risk group. Patients considered at high risk for developing post-operative complications had one or more of the following features:

- smokers or those who had ceased to smoke in the previous six weeks
- an FVC less than 80% and a FEV_1/FVC less than 75
- older than 60 years of age

The low risk group included the remainder of the sample who did not have any of the above features.

Each of the above two groups was then further divided into an experimental and a control group. The experimental group were seen by a physiotherapist once pre-operatively for instruction in lateral and posterior basal expansion, diaphragmatic breathing and coughing. Post-operatively these patients were seen twice daily for the first four days after extubation by the physiotherapist. At these sessions the patients were treated with the thoracic expansion exercises mentioned above in side lying and supine with the head of the bed raised 45 degrees. They were encouraged to cough both during and at the end of the treatment session. In addition they also received the ward regimen that included; incentive spirometry two hourly, nebulisation four hourly and turning, deep breathing and coughing every hour as administered by the nursing staff. The control group participated in the ward regimen only.

They concluded that the use of breathing exercises in high risk patients reduces the incidence of post-operative pulmonary complications, but is of no benefit in the low risk group.

The following factors should be borne in mind when interpreting this research. The routine ward procedure is far in excess to any programme that might be adhered to in the state hospitals in South Africa and so the conclusions may or may not be similar. It is not stipulated in the methodology whether the control groups received any input from the physiotherapist either pre-operatively or post-operatively. In this study percutaneous catheters were used to assist in lung clearance in patients with excessive secretions who were unable to cough effectively. In the experimental high risk group, none of the patients required the use of a percutaneous catheter, in contrast six out of thirteen patients in the high risk control group required their use. It is possible that the need to use percutaneous catheters arose as a result of the patients' lack of training or instruction in coughing, and not as a result of the thoracic expansion exercises. Lastly, the researchers omitted to mention the amount of active exercising in bed or walking, whether independently or assisted by the therapist, that the patients did post-operatively. The missing data from this research study may affect the interpretation of the results.

2.3.1 Physiotherapy in the intubated post-operative cardiac patient

On return from theatre, cardiac surgery patients typically spend the first 12 to 18 hours intubated and ventilated in the intensive care unit. Eales et al (1995) conducted a study to determine if routine physiotherapy for the intubated patient was necessary. They divided their patient population of 37 patients (27 valvular

surgery patients and ten coronary artery surgery patients) into three groups. The patients in all three groups were pre-oxygenated and suctioned. For the patients in group one this was the only treatment they received. The patients in group two were manually hyperinflated six times and then suctioned. Those patients in group three received six manual hyperinflations together with chest wall vibrations, administered during the expiratory phase, plus suctioning. Manual hyperinflation and vibrations have been shown to recruit collapsed lung units (Menkes and Traystman, 1977). It would thus follow that, in the presence of decreased breath sounds, a return to normal vesicular breath sounds may be expected on auscultation. These respective treatments were continued until the patients were clinically clear of secretions on auscultation. Unfortunately the post-treatment auscultation findings were not recorded in the results, and thus no conclusions can be drawn for the effectiveness of the above techniques in altering auscultation findings.

The results reported showed no significant difference in effective dynamic compliance, PaO_2 and the PaO_2/ FIO_2 ratio between any of the three groups. They thus concluded that a single physiotherapy treatment to the intubated post-operative cardiac patient was of no benefit. In keeping with the findings of the Eales et al. (1995) research, the patients in this study were not treated while still intubated.

2.3.2 Intermittent positive pressure breathing (IPPB), incentive spirometers (IS) and blow bottles

Iverson et al. (1978), in a study of 145 patients undergoing cardiac surgery, researched the effect that intermittent positive pressure breathing, incentive spirometry and blow bottles had on atelectasis. The study population was composed of 50 patients who underwent valvular surgery, 89 coronary artery surgery patients, and six patients who had 'miscellaneous" operations. All patients received pre-operative instructions in thoracic expansion exercises and coughing, in addition to one of the above modalities. The results showed that the intermittent positive pressure breathing group fared the worst with the greatest number of respiratory complications post-operatively. The group using blow bottles had the fewest complications. The results also showed that none of the above techniques prevented the atelectasis from occurring or improved it during the 72 hour study period.

Once again interpretation of the following results should be made with the following factors in mind. No mention is made of the patients' position during these treatments, or whether or not the patients were walking alone or with help at any stage. The definition of a pulmonary complication is not clearly stated and this makes comparisons to other studies difficult. The findings for the group who used incentive spirometry should be viewed with caution. The authors state that the pump times for this group were significantly longer than those of the other two

groups, a result of a change in operative procedure. Had the incentive spirometry group not had this confounding factor their results may have been different.

Gale and Saunders (1980) compared a Bartlett - Edwards incentive spirometer to intermittent positive pressure breathing in a group of patients who had undergone open heart surgery. The total sample of 109 patients was made up of 74 coronary artery surgery patients, 32 valvular surgery patients and 12 "miscellaneous" operations. A regime of pre-operative training in the use of the modality that they would use post-operatively was followed. Post-operative treatment consisted of four hourly use of this modality for a minimum of three days. They concluded that incentive spirometry is not significantly better than intermittent positive pressure breathing in preventing post-operative atelectasis. Following both forms of treatment there was a trend to hypoxaemia that was slightly greater in the intermittent positive pressure breathing group.

The results of this study are difficult to compare to other studies as no details are given concerning chest physiotherapy. It is thus presumed that the patients received no chest physiotherapy treatment. There is also no mention of walking or active bed exercise programmes that the patients may have followed during this time. It seems unlikely that a regimen of ten incentive spirometry breaths, or twenty intermittent positive pressure breaths alone, in a twenty minute treatment session is sufficient to have an effect on atelectasis.

Oikkonen et al. (1991) found similar results in a study in which either intermittent positive pressure breathing or incentive spirometry, were given together with conventional chest physiotherapy in a group of 52 coronary artery surgery patients. The conventional chest physiotherapy consisted of 'breathing techniques, deep diaphragmatic ventilation and efficient coughing'. The patients were trained in these techniques for two days pre-operatively. Post-operatively the patients received this conventional physiotherapy a minimum of once a day. They also received intermittent positive pressure breathing on four occasions during the day or, incentive spirometry every alternate waking hour. They concluded that the incidence of atelectasis in both groups increased during the study period. In other words, neither intermittent positive pressure breathing or incentive spirometry when added to conventional chest physiotherapy were able to prevent or improve the post-operative atelectasis that occurs following open heart surgery. Once again this research does not mention a bed exercise programme or at what stage the patients sat out of bed or walked. The position in which the physiotherapy was done in is also not included in the methodology.

Oulton et al. (1981) considered whether different incentive breathing devices added any benefit to a regimen of standard chest physiotherapy in a group of coronary artery surgery patients. They compared chest physiotherapy alone (which consisted of encouragement to cough, deep breathing, postural drainage, vibration and percussion) to chest physiotherapy plus either a Triflo spirometer or a Spirocare spirometer. All patients were taught how to use their chosen device pre-operatively. Their results showed that the group using the Spirocare spirometer

had less post-operative atelectasis on chest roentgenograms throughout the first four post-operative days than the other two groups. This was thought to be due to the Spirocare having an additional visual stimulus to hold maximum inspiration for three seconds. With the Triflo spirometer the balls will rise when a relatively small volume is inspired rapidly, and inspiratory hold is not encouraged (Oulton et al,1981).

It should be noted that postural drainage positions and patients' position while using the spirometers were not described. In addition, no information is given about patient mobility post-operatively. The authors state that after five patients had been entered into each group it was obvious that the spirocare group was faring the best. In interpreting this it is important to note that the groups were not well matched for age and this may have influenced the results. The mean age of the chest physiotherapy group was 45 years while the group using the Spirocare had a mean age was 60 years.

Stock et al. (1984) compared continuous positive airway pressure, incentive spirometry and conservative therapy in a group of elective open heart surgery patients. Of the sample of 38 patients, only five patients had valvular surgery while four had a combination of coronary artery surgery and valvular surgery. The remainder all had coronary artery surgery. Conservative therapy was considered four to five maximal inhalations, huffing and instruction to "cough heartily". No details were given about patient positioning for treatment or how soon the patients were made to walk or sit out of bed. Each treatment lasted fifteen minutes and

occurred every two waking hours for the first three post-operative days. This could lead to confounding results as it is felt that in clinical practice the effect of treatment should be evaluated on the clinical outcomes of that treatment and not be determined by a time period. They concluded that neither conservative chest physiotherapy, incentive spirometry or continuous positive airway pressure improved the restrictive lung function defect within the first 72 hours post-operatively.

From the studies discussed above it is difficult to draw conclusions. Some of these difficulties have been highlighted already. However, some of the factors not mentioned will now be discussed. The patient groups for the different studies were not standardised. Some groups consisted of patients undergoing different kinds of surgical procedures, while others were patients all undergoing the same procedure. This may be a confounding variable when trying to compare the studies. The inclusion and exclusion criteria are not always clearly stated and differ between studies. As has been mentioned previously, walking the patient has not been addressed, and thus is a poorly controlled variable. Patient position for "physiotherapy" techniques are also not consistently recorded and thus could play a role in the results of these studies. Chest physiotherapy it would seem has multiple definitions as no two studies used the same chest physiotherapy regime. Control groups who did not receive physiotherapy were never considered, and thus it is difficult to isolate the effect of physiotherapy.

2.3.3 Mobilisation

Dull and Dull (1983) compared early mobilisation alone to early mobilisation plus breathing exercises or incentive spirometry. Early mobilisation was defined as; "ankle circumduction, range of motion to all extremities, three maximal coughs, and encouragement and assistance to turn from side to side, sit up, or stand up." The study group included 29 patients who had coronary artery surgery and 20 who had valve replacement surgery. They found that neither of the "added" modalities (incentive spirometry or breathing exercises) were beneficial to the early mobilisation programme alone. In addition, none of the three programmes improved the lung function changes seen post-operatively.

For the purposes of this study a pulmonary complication was defined as:

- a temperature elevation of 4^{o} F above the mean pre-operative temperature
- a temperature elevation of 2 to 3^{o} F above the mean pre-operative temperature in addition to abnormal auscultatory findings
- purulent sputum.

Using these definitions the authors found that 77% of the patients who underwent coronary artery surgery and 92% of the valvular surgery patients developed a post-operative complication during their respective treatment programmes. They thus concluded that none of the treatment programmes was effective at preventing post-operative pulmonary complications. It is possible that the definition of a post-

operative pulmonary complication was too broad thus accounting for between 77% and 92% of patients developing such a complication.

In a study of 110 white males undergoing coronary artery surgery three different treatment protocols were assessed (Jenkins et al., 1989; 1990) The study population was divided into three groups. All the study participants were seen pre-operatively by a physiotherapist and were taught huffing, coughing with sternal support and active upper and lower limb exercises. The need to move about post-operatively and expectorate bronchial secretions was also explained. This was the only physiotherapy that the patients in the control group received post-operatively. The patients in the other two groups received either localised breathing exercises (with vibrations and percussion in a postural drainage position if deemed necessary) or incentive spirometry. The patients in both these groups were taught their respective techniques pre-operatively and encouraged to practice them. They found that adding breathing exercises or incentive spirometry to the programme of the control group, did not alter their treatment outcome. The authors recommended that the uncomplicated coronary artery surgery patient be taught, and helped with the mobility regimen.

Stiller et al. (1994) included a control group in their study which received no pre- or post-operative physiotherapy. This was the first study in which physiotherapy was completely excluded. The study population was made up exclusively of patients undergoing coronary artery surgery. The control group (group 1) followed the normal mobilisation protocol of the hospital which included sitting out of bed

on day two post-operatively and walking from day three. The patients in group 2 were seen pre-operatively and twice daily on days one and two, and once daily on days three and four post-operatively. At these sessions the patients were treated with a regimen of deep breathing exercises and coughing. The group three patients received the same treatment as described above for group 2. They differed from group two in that they had four treatments on days one and two, and two treatments on days three and four post-operatively. The results from this study were in agreement with the above two studies in that the incidence and severity of hypoxaemia, fever, chest x-ray abnormalities and significant pulmonary complications was not notably higher for the control group. Patients excluded from this study included those that were mechanically ventilated for more than 24 hours post-operatively, and those who developed a neurological or cardiac complication which rendered them unable to participate in the study. The recommendation of this study is that all patients be continually assessed for clinically significant pulmonary complications, and treated with physiotherapy if and when the need arises.

Stiller et al. (1994) make the following point. Although the control group received no pre-operative physiotherapy they did watch a video pre-operatively which mentions chest physiotherapy. In the process of giving informed consent to participate in the study, the patients were made aware of the rationale for doing breathing exercises and coughing post-operatively. It is possible that both these factors may have affected the behaviour of the control group.

A further study by Jenkins et al (1994), in which patients undergoing coronary artery surgery, were simply encouraged to take deep breaths and cough in addition to being mobilised by the nursing and surgical staff revealed results similar to the studies cited above. The incidence of respiratory complications post-operatively remained low (9%) despite the lack of chest physiotherapy. The patients excluded from this study included those who had had previous coronary artery surgery or pulmonary surgery and those that had a pre-operative respiratory abnormality.

In 1995 Stiller et al. investigated whether the incidence of clinically significant pulmonary complications had increased since the recommendation that routine post-operative physiotherapy was not necessary in the uncomplicated coronary artery surgery patient. The 1995 study included all patients undergoing heart surgery requiring cardiopulmonary bypass. The only difference in this study from the 1994 study was that it included 13 patients who had undergone cardiac valve surgery without coronary artery surgery. Clinically significant pulmonary complications were found in 7.1% (nine out of 127 patients) of the total patient population. An important consideration in this study is that all patients undergoing cardiac surgery were included and thus patients with significant pre-operative risk factors were also included.

When comparing all these studies described above it is clear that not only are the patient groups very different but so too are the outcome measures used. A respiratory complication has many different definitions some of which have been dealt with previously. The length of post-operative stay is also not always assessed

and this should be considered a vital outcome measure as it is the end point of the patients acute care phase.

In 1995 no research had been done exclusively on patients undergoing valve surgery. The question at the start of this study was whether the results of the above studies would apply to this particular patient population. Since collection of the data for this study a new study by Johnson et al (1996) has been published. Their study involved 75 patients who had undergone valve surgery. The patients were randomly divided into two groups. One group received a lower intensity treatment which included education, early ambulation, and deep breathing exercises, while the other group received the same treatment with the addition of single handed percussion (higher intensity treatment).

The patients were monitored for 5 days post-operatively and chest x-ray scores, lung function tests, duration of the intensive care unit and hospital stay were recorded. In addition personnel costs were calculated for both treatment groups. They found no significant differences between the groups and they had a 5% respiratory complication rate. For the purposes of their study a respiratory complication (pneumonia) was defined as the presence of three out of four of the following variables: a white blood cell count greater than 10^9/L; an oral temperature greater than 38.5 °C; a positive culture for a respiratory pathogen in the sputum and evidence of air bronchograms on chest x-ray.

In interpreting the results of this study it is of note that during the time period of this study 123 patients were admitted for valvular surgery with only 78 patients included initially. This means that 37% of the valve population were not included in the study sample. Exclusion criteria were: haemodynamic instability (this is not defined), inability of the patient to perform the pre-operative tests, inability to obtain informed consent and an intubation time of longer than 72 hours. In conclusion these results confirm that more treatment is not effective in preventing post-operative atelectasis, or improving post-operative lung function.

2.3.4 Paediatrics

One study was found in which the effects of post-operative physiotherapy on children were discussed. Although the age group discussed is younger than that of the subjects in this research report it is felt that the findings of this study should be documented for completeness sake.

In a study involving 50 children aged three months to nine years, undergoing cardiac surgery for congenital heart disease the following results were found (Reins et al. 1982) The group receiving chest physiotherapy (postural drainage with vibrations and cupping) in addition to deep breathing, coughing and suctioning developed atelectasis significantly more frequently than the non-treatment group. They also found that the chest physiotherapy group had a significantly longer post-operative hospital stay. They explain these startling findings as follows;

- lung compression from percussion over the child's compliant thorax, may have caused physical collapse of the airways or forced air out of the ventilated segments and allowed them to collapse.
- the pain induced by chest physiotherapy may have lead to splinting of the thorax resulting in a decreased functional residual capacity, resulting in collapse.

In conclusion to their study they recommended that chest physiotherapy be used with caution in this patient population and not as a routine treatment.

CHAPTER THREE

METHODS

3.1 Location

This study was carried out in the cardiothoracic unit of the Johannesburg hospital, Gauteng, South Africa. Patients requiring cardiothoracic surgery are admitted to this unit from other hospitals in the Gauteng region, with many of the referrals coming from the Chris Hani Baragwanath hospital in Soweto. Subsequent to the start of this study ethical clearance from the Committee for Research on Human Subjects of the University of the Witwatersrand was obtained (clearance number: M950331).

3.2 Inclusion criteria

i. All patients aged 10 years and older admitted for elective cardiac valve surgery, to the above unit, between 12 June 1995 and 1 September 1995.

ii. Written informed consent was obtained from the patients themselves, or in the case of minors, consent was obtained from the parent or legal guardian.

3.3 Exclusion and withdrawal criteria

i. Documentation of pulmonary disease (e.g. pulmonary tuberculosis) in the medical record.

ii. A pre-operative neurological disorder (for example, a cerebrovascular accident).

iii. Patients who were intubated for longer than twenty-four hours after anaesthetic, as prolonged intubation is a known risk for the development of pulmonary complications.

iv. Patients who returned from theatre with neurological or cardiac complications which rendered then unable to participate in the study.

v. Patients who spent more than forty-eight hours in the intensive care unit, as this suggested that the patient had not had a stable post-operative course.

3.4 The study population

Thirty-six subjects were included in the study of which six (17 %) were withdrawn during the post-operative study period. Three of the patients suffered a cerebrovascular accident during surgery or in the immediate acute post-operative period. One patient was intubated for longer than 24 hours, and the other two patients remained in the intensive care unit for longer than 48 hours due to cardiac instability. The pre-operative data collected for these six patients is not included in the statistical analysis of the results of

this study. However it was not significantly different from the data obtained for the other 30 patients.

Twenty-one females and nine males aged between eleven years and sixty-three years of age with a mean age of 29.72 years made up the study population. During the study period an additional two patients were admitted for valvular surgery who were not included in the study. The reasons for exclusion were documented histories of pulmonary tuberculosis.

3.5 Materials used:

i. A Detecto scale and ruler were used for all height and weight measurements.

ii. A standard oral thermometer was used for all temperature readings.

iii. Earlobe capillary blood was taken using a heparinised glass capillary tube (D953-7.5-130 clinitube).

iv. Blood gas analysis was done in a Ciba-Corning 288 blood gas system machine that was calibrated at 08h00 each morning according to the manufacturers' instructions.

3.6 Procedure:

Each patient participating in the study was assigned a number in sequential order of admission (patients' 1-36). This was done to ensure patient confidentiality, as the patient data was then collected and recorded under the patient number. The patients were then randomly assigned to one of two groups. An equal number of red and blue coloured tiddlywinks discs were placed in a bag. A colleague of the researcher who was uninvolved in the study then selected a disc for each patient. A red disc resulted in the patient being placed in group one (non-treatment group) and a blue disc in group two (treatment group). This resulted in the researcher knowing prior to the pre-operative interview to which group the patient had been assigned. All the patients received their post-operative instructions at this interview which was conducted by the researcher. The patients in the treatment group were told that they would be seen the morning after surgery.

3.6.1 Pre-operative procedure

The pre-operative interview took place 24 to 48 hours before the patient was scheduled for surgery. At the pre-operative interview, the following patient data was collected: age, sex, racial group, height (in meters), weight (in kilograms), past medical and surgical history, smoking history, present history and pre-operative medication. Racial grouping was classified according to the information on the admission sticker of the patient and was either "Black", "White",

"Coloured", or "Asian". The smoking history for patients still smoking at the time of the interview included the number of cigarettes smoked per day and the number of years for which the patient had smoked. "Past" smoking history included the above information and the length of smoking cessation.

Shoulder range of movement of all patients was tested pre-operatively. The test was simply noting and recording active range of shoulder flexion and abduction. The range of these movements was estimated and not measured as this is the routine in the unit.

Patients in the non-treatment group were instructed that they should try and cough regularly. In addition, on the second post-operative day they should, together with the help of the ward nursing staff, get out of bed and walk around the ward. They were informed that they would be routinely assessed throughout their stay in hospital by the doctors and the researcher.

The treatment group patients were instructed that they would be seen on days' one to four post-operatively and taught breathing exercises, assisted coughing and helped with walking on day two.

The first treatment for this group only commenced post-extubation as treatment during intubation in this patient population has been found to be no more successful than suctioning alone (Eales et al., 1995). The patients who were extubated were treated for the first time in the intensive care unit if they had not

been transferred to the ward yet. Those patients in the non-treatment group were assessed for the first time after extubation.

Finally a notice saying "Sue's MS atient" was placed in the patient's file so that all the ward staff and visiting physiotherapists would know that the patient was part of a study. This was done to prevent other therapists on the ward treating the patients in either group. All the physiotherapy treatments were done by the same physiotherapist working on the ward to insure that each patient in the treatment group received the same treatment.

During the post-operative period the patients were assessed daily by the cardiothoracic surgeon responsible for them. The surgeons involved were unaware as to which of the two groups the patients belonged.

A patient was considered to have a respiratory complication if all three of the following factors were present:

- the temperature was greater than 38.5^{0}C,
- there was radiological evidence of consolidation or collapse,
- there was evidence of respiratory infection clinically and on auscultation as decided by the cardiothoracic surgeon.

For the purpose of this study "chest clinically clear" refers to auscultation findings of normal breath sounds with no added sounds.

3.6.2 Non-Treatment Group

i. The following signs were assessed on each occasion by the researcher. Temperature, respiratory rate, auscultation of the thorax, chest radiograph if present and shoulder range of movement.

ii. The patients were seen twice by the researcher on days' one and two (once each in the morning and the afternoon) and once daily on days' three and four (in the morning) post-operatively.

iii. The patients were monitored daily for any post-operative complication as is the routine in the unit until discharge.

3.6.3 Treatment Group

i. Assessed in the same manner as described for the non-treatment group.

ii. Following the assessment session the patients received physiotherapy as described below.

iii. The treatment involved the patient supine in bed with pillows behind the back and the head. The degree of head and trunk elevation was a minimum of 45 degrees. The physiotherapist taught the patient "deep breathing exercises" and supported coughing. Deep breathing exercises were defined as lateral costal

expansion followed by passive expiration with a rib spring at the end of expiration to stimulate a deep inspiration. Supported coughing included a pillow or the patients' hands being held against the incision site to support the wound during coughing. This combination of breathing exercises and coughing was continued until the physiotherapist assessed that the auscultation findings were clinically clear or improved from the pre-treatment findings and that the patients' cough was effective and unproductive. If the patients' chest was assessed as clinically clear prior to treatment the patient did not receive a treatment. In this study no patients' were assessed as clinically clear prior to treatment. The same procedure was followed during the second treatment in the afternoon.

iv. On day two, after the removal of the mediastinal and intercostal drains, the patients were walked "around the ward" (a distance of 45 meters) in addition to the treatment described above. The same treatment was repeated in the afternoon. On day three the treatment was the same as that described for day two, except the distance walked was increased to 90 meters. The patients were allowed to walk as much as they wanted to, excluding stairs, during the remainder of the day.

v. On day four the treatment was the same as that described above for day three. Treatment was discontinued after day four and the patients were instructed to continue walking and coughing as necessary.

vi. As with the non-treatment group, the patients were monitored daily until discharge as is routinely done in the unit.

3.7 Data collected

i. Oral temperature (degrees Celsius) was recorded pre-operatively and daily on days' one to four at 06h00 by the nursing staff in the ward and recorded as part of the medical record.

ii. Respiratory rate (breaths per minute) was recorded pre-operatively and daily on days' one to four prior to treatment or assessment by the researcher. All the respiratory rates were counted over one full minute.

iii. A record was kept by the researcher of the patients' pre-operative and post-operative medication up to and including day four.

iv. Earlobe capillary blood gases were taken pre-operatively, on days' one and four. These were taken using a capillary tube and analysed immediately. The sampling technique used was that described by Spiro and Dowdeswell (1976) All blood gases were sampled with patient breathing room air, i.e. an FIO_2 of 0.21, and sitting in long sitting in bed. If the patient was on supplemental oxygen the blood gas was sampled 15 minutes after the supplemental oxygen had been removed. In group two the blood gases were taken one hour after treatment.

From these blood gases the following were recorded; PaO_2 (mmHg), $PaCO_2$ (mmHg) and percentage saturation. Calculations were done using the above information to determine the PaO_2/FIO_2 ratio and the $P(A\text{-}a)O_2$ difference.

v. Chest radiographs were taken pre-operatively, and on days' one, two and four post-operatively. Pre-operatively and on days' two and four, postero-anterior (PA) and lateral views were taken. On the first post-operative day (day one) a portable antero-posterior (AP) view was taken and there was no lateral view. This was as a result of the patients remaining in the intensive care unit until the radiographs had been taken as is the policy of the unit. All these chest radiographs were scored by the same radiologist in the radiology department of the University of the Witwatersrand.

The radiologist scoring the radiographs was unaware of the group assignment of individual patients.

The same radiologist scored 10% of the x-rays six weeks after the initial scoring and 100% correlation was found with the initial scores thus proving inter-scorer reliability.

The chest radiographs were scored in the following way:

Each lung was scored individually and then the totals were added together. The location and type of abnormality were recorded and the presence of pleural effusion was documented.

The scores were allocated as follows:

0 No abnormalities were noted and the lung fields were assessed to be radiologically clear.

3 Minor collapse/ consolidation at one base, involving 1-3 bronchopulmonary segments.

7 Pronounced collapse/ consolidation and/ or both at one base involving an entire lobe.

15 Bilateral collapse and / or consolidation and / or patchy infiltrates were noted.

This scoring system was used in a previous study by Stiller et al. (1994) with no documented disadvantages and so it was thought to be accurate for this type of study. There were however some problems with it not being sensitive enough to radiological changes. This problem will be discussed in the discussion.

vi. On day one the following intra-operative data was collected:

a. The type of operation done (valve replacement, repair, annuloplasty).

b. The type of valve that was used (homograft, mechanical valve or ring).

c. The size of the artificial valve (mm).

d. The duration of the anaesthetic (in minutes).

e. The duration of the cardiopulmonary bypass (in minutes).

f. The aortic cross clamp time (in minutes).

vii. The time (in hours) from the end of the anaesthetic to extubation was also recorded.

viii. For the treatment group patients the duration of the physiotherapy treatment was recorded.

ix. The length of post-operative stay in hospital was recorded for all the patients in the research project.

3.8 Calculations:

i. From the height (m) and the mass (kg) the body mass index for each patient was calculated using the following formula:

$$\text{Body Mass Index} = \text{mass (kg)}/\text{height (m)}^2$$

ii. From the smoking history the number of pack-years was calculated:

$$\text{Pack-year} = (\text{number of years} \times \text{number of cigarettes per day})/20$$

iii. The PaO_2/FIO_2 ratio was calculated in the following way:

$$\frac{\text{Partial pressure of oxygen } (PaO_2)}{\text{fraction of inspired oxygen } (FIO_2)} = \frac{PaO_2 \text{ (mmHg)}}{FIO_2}$$

iv. The $P(A\text{-}a)O_2$ difference was also calculated using the following formula:

$$P(A\text{-}a)O_2 = \left(FIO_2 (\text{Atmospheric pressure} - PH_2O) - \frac{PaCO_2}{\text{Respiratory quotient}} \right) - PaO_2$$

$$P(A\text{-}a)O_2 = \left(0.21 \times (620 \text{ mmHg} - 47 \text{ mmHg}) - \frac{PaCO_2}{0.8} \right) - PaO_2$$

3.9 Statistical analysis:

All the data collected was statistically analysed by the Medical Research Council of South Africa.

Means, standard deviations and frequency distributions were used to summarise the data. Comparisons were made between the non-treatment and the treatment groups using the Mann - Whitney rank sum test, which is the non - parametric equivalent of the student's "t" test. A non parametric test was used due to the continuos nature of the data.

Within-subject comparisons were made for repeated measurements. for example PaO_2 using the Wilcoxon test.

The chi-square test was used to test for associations between the relevant variables. When the frequency was less than five, the Fisher's exact test was used.

A "p" value of less than 0.05 was considered to be statistically significant in this research report.

The sample size was determined using the programme Epi Info 6. The power of the study was calculated and a sample size of 24 was recommended for a confidence level of 95%.

CHAPTER FOUR

RESULTS

4.1 Age, sex and racial group

The mean age of the participants in the treatment group was not significantly different to the mean age of the non-treatment group ($p > 0.05$) (Table 4.1). The age range for the non-treatment group was 11 years to 50 years with a mean of 28.43 years and in the treatment group from 11 years to 63 years with a mean of 31 years. The demographic data for each patient can be found in appendix 1 (page 74).

The distribution of males and females between the two groups was significantly different ($p < 0.05$). The non-treatment group had 12 females and two males, and the treatment group had eight of each in it. Of the total study population 66.6 % were female.

In the non-treatment group all the subjects were Black while in the treatment group 81.25% were Black, 6.25% Asian and 12.5% White. There was however no significant difference between the two groups ($p > 0.05$) (table 4.1).

Table 4.1 Age, sex and racial group of participants in the study

Variable	Group	n		Mean	S.D.	"p"
Age	NTR	14		28.43	±11.12	0.68
	TR	16		31	±15.21	NS
		n		Male	Female	"p"
Sex	NTR	14		2	12	0.02
	TR	16		8	8	Sig
		n	Black	Asian	White	"p"
Race	NTR	14	14	0	0	0.23
	TR	16	13	1	2	NS

NTR = Non treatment group/ TR = Treatment group

4.2 Height, weight and body mass index

There was no significant difference in height (in meters), weight (in kilograms) and body mass index (kg/m^2) between the two groups ($p > 0.05$) (table 4.2).

Table 4.2 Mean height, weight and body mass index of participants in the study

Variable	Group	n	Mean	S.D	"p"
Height	NTR	14	1.52	±0.09	0.16
(meters)	TR	16	1.56	±0.17	NS
Weight	NTR	14	52.74	±0.09	0.74
(Kilograms)	TR	16	51.83	±18.79	NS
BMI	NTR	14	22.40	±5.16	0.28
(Kg/m^2)	TR	16	20.59	±4.84	NS

NTR = Non treatment group/ TR = Treatment group

4.3 Type of operation

Tables 4.3.1 and 4.3.2 show details of the valves operated on and the type of operations done.

Table 4.3.1. Valves operated on

Group	n	AV & MV	MV & TV	MV	AV, MV & TA	AV & TV	AV
NTR	14	2	5	6	1	0	0
TR	16	3	4	6	0	1	2

AV = Aortic valve, MV = Mitral valve, TV = Tricuspid valve, NTR = Non treatment group/ TR = Treatment group

Table 4.3.2. Type of operation done

Group	n	Repair (MV)	Replacement Homograft (AV)	Replacement Mechanical (AV or MV)
NTR	14	6	2	6
TR	16	5	0	15

NTR = Non treatment group/ TR = Treatment group

Repairs are reserved for the mitral valve, while homografts are used as the replacement for an aortic valve in some patients. Mechanical valve replacements include both aortic and mitral valves which could not be repaired.

4.4 Duration of anaesthesia, cardiopulmonary bypass, aortic cross clamp and intubation

There was no significant difference between the two groups in terms of the duration of the anaesthetic, cardiopulmonary bypass, aortic cross clamp or mechanical ventilation ($p > 0.05$) (table 4.4).

Table 4.4 Mean duration and S.D. of anaesthesia, cardiopulmonary bypass, aortic cross clamp and intubation

Variable	Group	n	Mean duration (minutes)	S.D	"p"
Anaesthesia	NTR	14	255.14	±59.20	0.8
	TR	16	256.25	±59.37	NS
CPB	NTR	14	108.36	±39.26	0.87
	TR	16	110.69	±39.00	NS
Aortic cross clamp time	NTR	14	74.93	±34.29	0.79
	TR	16	73.31	±35.15	NS
			(hours)		
Intubation time	NTR	14	12.86	±2.93	0.1
	TR	16	15.06	±2.84	NS

NTR = Non treatment group/ TR = Treatment group

There were two patients who smoked in the non-treatment group, and one in the treatment group. They had pack years of 32, 3.5 and 10 respectively.

4.6 Chest X-rays

The pre-operative chest x-ray scores were not significantly different ($p > 0.05$) between the two groups. One subject in the treatment group had minimal atelectasis in the left lung pre-operatively. This did not change throughout the four post-operative days and was still present on day four.

The day 1, day 2 and day 4 chest x-ray scores were also not significantly different between the two groups ($p > 0.05$) (table 4.6). There was however a significant difference ($p = 0.001$) between the pre-operative chest x-rays and the day 1, day 2 and day 4 chest x-rays There was no significant difference between the day 1 and day 2 x-rays ($p = 0.109$), the day 1 and day 4 x-rays ($p = 0.234$) or the day 2 and day 4 chest x-ray scores ($p = .0.1$). The chest x-ray scoring system may be found on page 35. The raw data for the chest x-rays may be found in appendix 3 (page 78).

Table 4.6 Chest x-ray scores for all patients, pre-operative to day 4

	Group	n	Mean score pre-op	Mean score day 1	Mean score day 2	Mean score day 4
	All	30	0.10	1.60	2.200	2.100
S.D			±0.54	±2.19	±2.075	±2.107

NTR = Non treatment group/ TR = Treatment group

4.7 Partial pressure of oxygen in earlobe capillary blood (PaO_2)

The pre-operative values for PaO_2 were not significantly different when comparing the two groups. On day one there was no statistical difference between the two groups however, the "p" value may be of clinical significance (p = 0.07). The day four mean PaO_2 values were not statistically or clinically significant when comparing the two groups (table 4.7.1).

Table 4.7.1 Pre-operative, day 1 and day 4 mean and S.D. PaO_2 values

Group	n	Mean PaO_2	S.D.	"p"
Pre-op NTR	14	78.75	±16.43	0.68
Pre-op TR	16	78.32	±11.90	NS
Day 1 NTR	14	71.38	±17.27	0.07
Day 1 TR	16	60.35	±14.10	NS
Day 4 NTR	14	58.91	±9.27	0.92
Day 4 TR	16	57.83	±8.26	NS

NTR = Non treatment group/ TR = Treatment group

If one compared the pre-operative PaO_2 means for the group as a whole to the day 1 and day 4 PaO_2 means there was a significant difference ($p < 0.05$). However there was no significant difference ($p = 0.098$) between the values on day 1 and day 4 (table 4.7.2).

Table 4.7.2 Pre-operative, day 1 and day 4 mean and S.D. PaO_2 values for all subjects

	n	Mean PaO_2 pre-op	Mean PaO_2 day 1	Mean PaO_2 pre-op	Mean PaO_2 day 4
Both	30	78.520	65.499	78.520	58.340
S.D		±13.942	±16.363	±13.942	±8.608
"p"		0.002		0.000	
"p"			0.098		

" p value between pre-operative PaO_2 and day 1 PaO_2

" p value between pre-operative PaO_2 and day 4 PaO_2

" p value between day 1 PaO_2 and day 4 PaO_2

4.8 PaO_2 / FIO_2 ratio

The pre-operative values for the PaO_2 / FIO_2 ratio was not significantly different when comparing the two groups. On day 1 there was no statistical difference between the two groups however, as described above, there was a "p" value of clinical significance ($p = 0.07$). The day 4 means were not statistically or clinically significant (*table 4.8.1*).

Table 4.8.1 Pre-operative, day 1 and day 4 mean and S.D. PaO_2 /FIO_2 values

Group	n	Mean PaO_2 / FIO_2	S.D.	"p"
Pre-op NTR	14	375.01	±78.26	0.68
Pre-op TR	16	372.96	±56.68	NS
Day 1 NTR	14	339.91	±82.22	0.07
Day 1 TR	16	287.39	±67.13	NS
Day 4 NTR	14	280.54	±44.13	0.92
Day 4 TR	16	275.41	±39.35	NS

NTR = Non treatment group/ TR = Treatment group

On comparing the pre-operative group mean PaO_2 / FIO_2 ratio to the day 1 and day 4 group means there was a significant difference ($p < 0.05$) on both days. However there was no significant difference ($p = 0.098$) between the values on day 1 and day 4 (table 4.8.2).

Table 4.8.2 Pre-operative, day 1 and day 4 group mean and S.D. PaO_2 /FIO_2

n	Mean pre-op PaO_2 / FIO_2	Mean day 1 PaO_2 / FIO_2	Mean pre-op PaO_2 / FIO_2	Mean day 4 PaO_2 / FIO_2
Both 30	373.920	311.903	373.920	277.809
S.D	±66.392	±77.922	±66.392	±40.992
"p"	0.002		0.000	
"p"		0.098		

- p value between pre-operative PaO_2/FIO_2 and day 1 PaO_2/FIO_2
- p value between pre-operative PaO_2/FIO_2 and day 4 PaO_2/FIO_2
- p value between DAY 1 PaO_2/FIO_2 and day 4 PaO_2/FIO_2

4.9 The alveolar - arterial oxygen difference ($P(A\text{-}a)O_2$)

The pre-operative values for the $P(A\text{-}a)O_2$ difference were not significantly different when comparing the two groups. On day 1 there was no statistical difference between the two groups and unlike the previous two values, the "p" value was not of as much clinical significance ($p = 0.09$). The day 4 means were not statistically or clinically significant between the two groups (table 4.9.1).

Table 4.9.1 Pre-operative, day 1 and day 4 mean and S.D. $P(A\text{-}a)O_2$ values

Group	n	Mean	S.D.	"p"
Pre-op NTR	14	32.79	±15.82	0.9
Pre-op TR	16	32.28	±11.35	NS
Day 1 NTR	14	38.19	±17.62	0.09
Day 1 TR	16	49.12	±14.09	NS
Day 4 NTR	14	53.13	±8.84	0.87
Day 4 TR	16	54.25	±7.87	NS

NTR = Non treatment group/ TR = Treatment group

On comparing the pre-operative group mean $P(A\text{-}a)O_2$ difference to the day 1 and day 4 group mean $P(A\text{-}a)O_2$ difference, a significant difference ($p < 0.05$) was found. There was also a significant difference between the group mean $P(A\text{-}a)O_2$ difference between day 1 and that of day 4 (table 4.9.2).

Table 4.9.2 Pre-operative, day 1 and day 4 group mean and S.D. $P(A\text{-}a)O_2$

	n	Mean pre-op $P(A\text{-}a)O_2$	Mean day 1 $P(A\text{-}a)O_2$	Mean pre-op $P(A\text{-}a)O_2$	Mean day 4 $P(A\text{-}a)O_2$
Both	30	32.522	44.027	32.522	53.723
S.D		±13.377	±16.513	±13.377	±8.208
"p"		0.004		0.000	
"p"			0.022		

- p value between pre-operative $P(A\text{-}a)O_2$ and day 1 $P(A\text{-}a)O_2$
- p value between pre-operative $P(A\text{-}a)O_2$ and day 4 $P(A\text{-}a)O_2$
- p value between day 1 $P(A\text{-}a)O_2$ and day 4 $P(A\text{-}a)O_2$

Oxygen saturation data for each patient can be found in appendix 2 (page 75).

4.10 Temperature (°C)

There was no significant difference in temperature between the two groups throughout the duration of the study.

When comparing the mean group temperature of day 1, day 2, day 3 and day 4 to the mean pre-operative temperature there was a significant difference (p = 0.000) for each of the days. There was also a significant difference in mean temperature between day 1 and day 2 (p = 0.009), day 1 and day 3 (p = 0.000), and day 1 and day 4 (p = 0.000). The day 2 temperature was significantly different (p = 0.000) from the day 4 temperature but not from the day 3 mean temperature (p = 0.33), and the day 3 temperature was significantly different (p = 0.001) from the day 4 temperature.

The highest temperatures were recorded on day one post-operatively, where one patient in group one recorded a temperature of 38.7 °C and two patients in group two recorded temperatures of 38.6 °C.

The pre-operative and post-operative temperature for each patient can be found in appendix 2 (page 76).

4.11 Respiratory rate (breaths / minute)

There was no significant difference in respiratory rate between the two groups throughout the duration of the study.

When comparing the mean group respiratory rate of day 1, day 2, day 3 and day 4 to the mean pre-operative respiratory rate there was a significant difference (p = 0.000) for each of the days. There was no significant difference in mean respiratory rate between day 1 and day 2 (p = 0.107) and day 1 and day 3 (p = 0.719). Between day 1 and day 4 there was a significant difference in mean respiratory rate (p = 0.027).

The day 2 respiratory rate was significantly different (p = 0.000) from the day 4 respiratory rate but not from the day 3 mean respiratory rate (p = 0.315), and the day 3 respiratory rate was significantly different (p = 0.019) from the day 4 respiratory rate.

The pre-operative and post-operative respiratory rate for each patient can be found in appendix 2 (page 77).

4.12 Relationship between temperature and chest x-rays

In order to establish if there is a correlation between atelectasis detectable on chest x-ray and temperature in this group of patients a correlation analysis was done for each of the days where both variables were measured. There seemed to be little statistical relationship between chest x-ray changes and temperature (table 4.12).

Table 4.12 Correlation between temperature and chest x-ray scores

	n	r	r^2	%	"p"
Pre-op	30	+0.037	0.192	19.0	0.846
Day 1	30	-0.106	0.325	32.50	0.577
Day 2	30	+0.066	0.257	25.7	0.729
Day 4	30	-0.225	0.474	47.4	0.232

r = correlation coefficient; r^2 = coefficient of determination, NTR = Non treatment group/ TR = Treatment group

4.13 Length of hospital stay

There was no significant difference in length of post-operative hospital stay between the two groups (table 4.13).

Table 4.13 Mean duration and S.D. of length of stay in hospital

Group	n	Mean stay (days)	S.D	"p"
Non-treatment	14	10.29	±3.49	0.61
Treatment	16	11.31	±4.64	NS

In appendix 4 (page 79) the pre-operative and post-operative medication is listed for each patient included in the study.

CHAPTER FIVE

DISCUSSION

As there were no significant differences in the mean age, weight, height and body mass index of the two groups it may be assumed that the groups were well matched. The one significant difference between the two groups was the greater number of females in the non-treatment group. This difference is not thought to be of great importance as it is typical of this particular patient population.

5.1 Age, sex and racial group

The mean ages of the subjects in this study (28.43 and 31) were representative of the population normally affected by rheumatic heart disease in under developed countries (Marcus et al., 1994; Argawal et al, 1995). Only five of the thirty patients were over 40 years of age. When comparing this study to those of Johnson et al. (1996), Stiller et al. (1994), Jenkins et al. (1989) and Dull and Dull (1983) the mean age is much lower in this study. The patients who had undergone valvular surgery in the Dull and Dull study had a mean age range of 58.7 ±14.4 to 63.4 ±10.5 years, and those in the Johnson et al.study had a mean age of 63 ± 12 and 68 ± 10 years.

Of the total study population 66.6% were female. This is again representative of the population typically affected by rheumatic heart disease (Marcus, 1994; Agarwal et al., 1995). This factor is also different to the three studies mentioned above in that Jenkins et

al. (1989) only looked at male subjects while Stiller et al. (1994) had 98 males and only 22 females in their study, and Dull and Dull (1983) had 11 males and 9 females in their valve population and Johnson et al (1996) had 35 males and 40 females.

Concerning the race group of the subjects, 90% of the subjects were "black". This again is typical for the population in South Africa affected by rheumatic heart disease (Barlow, 1992a).

5.2 Height, weight and body mass index

There was no significant difference between the two groups for each of the above variables. The mean body mass index for the two groups was in the desirable healthy range indicating that obesity was not an operative risk factor, as was the case in the studies involving coronary artery surgery patients by Stiller et al. (1994) and Jenkins et al. (1989) and the valvular surgery patients in the Johnson et al study (1996).

5.3 Type of operation

The most commonly affected valve in this group of patients was the mitral valve with 80% of the patients having surgery of some type to this valve. This again is in keeping with the literature on rheumatic valve disease (Barlow, 1992a). However it is different to the valve population described by Johnson et al (1996) where most of the valve replacements were to the aortic valve (43 aortic valve replacements and 16 mitral valve

replacements). Twenty percent of the patient population underwent double valve surgery thus contributing to a longer cardiopulmonary bypass time and aortic cross clamp time.

The type of surgery performed (11 repairs, 2 homograft replacements, and 21 mechanical valve replacements) is typical of the units' policy. Where possible the affected valve will be repaired, if this is not possible a valve replacement will be done. Most replacements are done with mechanical valves because of difficulty in obtaining homografts. This is not an ideal surgical outcome when one considers that the patient population is largely composed of woman of childbearing age and the enforced anti-coagulation therapy post-operatively poses a risk during pregnancy and childbirth. It also means that patients will have to comply with the anti-coagulation regime and regular prothrombin index monitoring. This may pose a problem as many of the patients are classically from poor socio-economic environments and return to rural areas with limited access to medical care.

5.4 Duration of anaesthesia, cardiopulmonary bypass, aortic cross clamp and intubation.

There was no significant difference between the two groups with regard to duration of anaesthetic, cardiopulmonary bypass and aortic cross clamp time. The two groups were thus well matched for their intra-operative details.

The length of time the patients were intubated post-operatively was also not significantly different between the two groups.

Duration of anaesthetic in this study was considerably longer (255.14 ± 59.2 and 256 ± 59.37), than that reported by Stiller et al. in 1994 (156.8 ± 29.7, 155 ± 39.5 and 157.5 ± 31.7). Cardiopulmonary bypass time was also longer in this study at 108.36 ± 39.26 and 110.69 ± 39 as opposed to the longest mean time reported by Stiller at 43.4 ± 21.5. This may have been due to the fact that 20% of the patient population had double valve replacements and a further 33.3% had valve replacements as well as an annuloplasty. It should be borne in mind that the patients in the Stiller et al. study all had coronary artery surgery and thus direct comparisons are difficult. There is however no data available for patients undergoing valvular surgery.

Although the intubation time in this study was longer than that reported by Stiller et al. (1994) it is not thought to be significantly longer. This longer time may be explained in part by the longer anaesthetic time. These longer times did not seem to influence the results in this study as might have been expected as increased duration of both anaesthesia and intubation with mechanical ventilation are known to increase post-operative complications.

5.5 Smoking history

Only three subjects in the total study population had smoking histories, two of whom were in the non-treatment group. They had pack years of 32 and 3.5 respectively and the patient with the 32 pack years had ceased smoking one year prior to the operation, the other patient smoked up to admission into hospital. One subject in the treatment group

had a smoking history of 10 pack years and was a smoker at the time of the operation. Again the incidence of smoking in this study is lower than that reported by Stiller et al. (1994) and Jenkins et al. (1989). This may be attributed to the contribution of cigarette smoking to coronary artery disease. It would seem logical to question the role of post-operative physiotherapy in the presence of limited post-operative risk factors (age, obesity and smoking), and an uncomplicated post-operative course. However, as explained previously, there is often a degree of pulmonary oedema in these patients pre-operatively. It was this fact that prompted this research project.

5.6 Chest x-rays

When considering the chest x-ray scores there were no significant differences between the two groups for any of the days (pre-operative, day 1, day 2 and day 4). However, there was a highly significant difference between the pre-operative scores and the day one, two and four scores for both groups. There was no significant difference between the scores for any of the post-operative days. These findings are in agreement with previous studies (Gale and Saunders, 1980; Stock et al, 1984; Jenkins et al, 1989; Oikkonen et al, 1991; Stiller et al, 1994, Johnson et al, 1996). When looking at the group mean, the right lung, particularly the lower lobe, was more affected than the left lung for the entire post-operative period (see appendix 3, page 78). This is in contrast to the findings by Stiller et al (1994) in which the left lower lobe was predominantly affected. This difference may be due to a difference in operating technique. Pleural effusions were also noted in 10 patients and these either improved, or remained the same, throughout the duration of the study. The results above would suggest that the radiological changes

present on day one were not influenced by the addition of chest physiotherapy for the duration of the study period. This would suggest that physiotherapy provided no advantage in this group of uncomplicated post-operative patients.

On scoring the x-rays the radiologist felt that the scoring system may not have been sensitive enough particularly in the grade 0 - 3 category as often the patient was scored a 3 for one day and still scored a three the next day when in fact the x-ray had either improved or deteriorated but not enough to move into a new score bracket. It is not felt that this was a major problem as this applied to both groups of patients and the changes in the x-rays were never great enough to warrant a change in the scoring system used. It is also considered that the scoring system was accurate enough to pick up significant changes in the lung fields and that a more accurate system would not have affected the results in any way.

5.7 Partial pressure of oxygen in arterial blood (PaO_2), PaO_2 / FIO_2 ratio and the alveolar - arterial oxygen difference ($P(A-a)O_2$)

The blood gas values and calculated values all revealed similar findings. A profound hypoxia was present post-operatively in both groups which worsened with the duration of the study and on which chest physiotherapy seemed to have little or no effect. The only effect visible from physiotherapy was in fact a clinically significant decrease in the partial pressure of oxygen after a physiotherapy treatment on the first post-operative day. This unexpected decrease may be attributed to the effects of a "vigorous" session of physiotherapy which often causes pain and anxiety resulting in shallow breathing after

treatment and thus a worsening of the hypoxia. The PaO_2 / FIO_2 ratio followed the same pattern as described above. This ratio gives an indication of the degree of intrapulmonary shunting or physiological dead space, that is alveoli that are perfused but not ventilated. This would suggest that these patients have areas of atelectasis - a fact that has already been confirmed by the chest radiographs. It is debatable whether the degree of atelectasis visible on x-ray can fully explain the degree of shunting as evidenced by the PaO_2/ FIO_2 ratio (Hedley-Whyte et al., 1965).

The $P(A\text{-}a)O_2$ difference also followed the trends described above. However, in addition to the above, there was a significant difference between the value obtained on day one and that obtained on day four for the group as a whole. This calculation gives an indication of the diffusion characteristics of the lung. Cardiopulmonary bypass is known to increase the alveolar-arterial oxygen difference (Hewson, 1978). In this study it may be postulated that the underlying lung "flooding" that is present pre-operatively may be resolving by day 4 post-operatively as a result of the corrective operative procedure.

5.8 Temperature

There was no significant difference in the mean temperatures between the two groups for each of the days recorded. As described in the results there were significant differences in the mean temperatures for both groups between post-operative days. The day one temperatures were the highest for all subjects, with three subjects having temperatures above 38.5 ^{o}C. Although this is defined as one of the parameters for a respiratory complication, no subject was described by the surgeons as having a respiratory complication for the duration of the study period. The higher temperatures, above 38 ^{o}C,

recorded as a group on day one post-operatively are typical of patients having undergone cardiac surgery and are thus in agreement with the literature (Roses et al, 1974 and Wilson et al, 1988).

One patient in the treatment group spiked a temperature and showed signs of respiratory distress on day four post-operatively but these clinical signs were attributed to the development of a large left pleural effusion which was confirmed on chest x-ray and ultrasound.

5.9 Relationship between temperature and chest x-rays

A typical clinical observation by the surgeons in the unit in which this study was carried out is that of a temperature post-operatively being the result of atelectasis. In order to determine whether this assumption was correct a regression analysis was run for each of the following days, pre-operative, day one, day two and day four. There was found to be very little correlation between temperature changes and chest x-ray findings viz. atelectasis. This finding is in agreement with a study done by Engoren (1995) in which he found no association between radiographically diagnosed atelectasis and fever in 100 post-operative cardiac surgery patients. It is thus concluded that temperature is not a sensitive indicator of atelectasis.

5.10 Length of post-operative hospital stay

There was no difference in length of post-operative hospital stay between the two groups.

The shortest post-operative stay was five days while the longest was 22 days. The latter patient being the one that developed the large pleural effusion on day four post-operatively. The mean stays of 10.29 and 11.31 are comparative to the studies by Stiller et al, (1994) and Johnson et al, (1996). Thus in terms of cost effectiveness, chest physiotherapy provided no benefit in terms of shortening the length of post-operative hospital stay. Since the early research done in this field, operative and anaesthetic techniques have undoubtedly improved. Antibiotic cover is also possibly better understood and more readily available to the post-operative patient. All patients in this study were prophylactically put on Cephazolin (Kefzol), one gram eight hourly, for a minimum of 48 hours post-operatively as is the policy of the unit. Possibly it is a combination of these factors that has diminished the need for routine post-operative physiotherapy in this uncomplicated patient population.

5.11 Cost effectiveness of chest physiotherapy

If one considers the cost of a single chest physiotherapy treatment to be R 37.40 in 1997, then the total cost of treating the patients in the study group would have been 16 multiplied by R 37.40 multiplied in turn by six treatments resulting in a total of R 3 590.40. If the treatments took place over the weekend, the rates are then increased to R 56.10 per treatment.

It is difficult in today's pressurised economic situation to justify the ongoing use of staff time and state funding for treatments that are ineffective. It should be emphasised that these results are only applicable to the patient population described in this study and

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It is difficult in today's pressurised economic situation to justify the ongoing use of staff time and state funding for treatments that are ineffective. It should be emphasised that these results are only applicable to the patient population described in this study and

cannot be considered applicable to other patient populations. Continual post-operative assessment and walking of the patient as soon as possible is the recommended course of action. Continual assessment will allow complications to be followed up, and chest physiotherapy instituted if the need arises.

Another factor to be considered in this research is the role of the pre-operative interview. All patients were interviewed and received some kind of directive. It is possible that this contact with the patients pre-operatively played some role in the post-operative outcome.

5.12 Recommendations

From the results of this study the following recommendations can be made:

i) Patients admitted for elective heart valve surgery with no documented history of pulmonary disease should be assessed daily and only treated should a respiratory complication arise. It is considered that a pre-operative treatment session is unnecessary. A pre-operative assessment of the patients pulmonary status may help to highlight possible post-operative risk factors.

ii) Patients with a documented history of pulmonary disease should be assessed daily and treated as the pre- and post-operative situation demands.

iii) All post-operative cardiac patients should be mobilised out of bed on day two post-operatively or as soon as their haemodynamic status allows.

iv) Interpreting the cause of a post-operative temperature as atelectasis, should be done with caution and only in the presence of a chest radiograph to confirm the diagnosis.

v) The time spent treating these patients should be used to educate the patients with regards to exercise regimes post-operatively.

Recommendations in terms of further research:

i) A further study needs to be carried out where the recommendations of this study are put into practise to determine if the results and recommendations of this study are valid and accurate.

ii) The paediatric population has not been addressed in terms of their need for prophylactic physiotherapy following cardiac surgery. This study needs to be undertaken.

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