1992

Comparison of pulmonary artery pressure measurements in the supine and lateral positions

Leanne Maree Aitken
Edith Cowan University

Edith Cowan University

Copyright Warning

EDITH COWAN UNIVERSITY

SCHOOL OF NURSING

BACHELOR OF NURSING - HONOURS

COMPARISON OF PULMONARY ARTERY PRESSURE

MEASUREMENTS IN THE SUPINE AND LATERAL POSITIONS

Name: LEANNE MAREE AITKEN

Student Number: 0872285

Student Address: 75 New Town Road
                   NEW TOWN, Tasmania 7008
                   Phone (H) 002 781873
                         (W) 002 388212

Date Submitted: 20th July, 1992

USE OF THESIS

The Use of Thesis statement is not included in this version of the thesis.

ABSTRACT

Pulmonary artery pressure monitoring, with the patient in both the supine and lateral position, constitutes an essential element of assessment in the critically ill. Previous work offers conflicting results regarding the accuracy of pulmonary artery pressure measurements obtained with the patient in the lateral position. Additionally, recent studies question the most appropriate thoracic surface landmark for use as the zero point for pulmonary artery pressure monitoring.

The purpose of this study was to identify a reliable surface landmark to be used as the zero point for pulmonary artery pressure monitoring, as well as to determine if use of that zero point provided accurate pulmonary artery pressure measurements when the patient was in either the left or right 60° lateral position. Specifically, these questions were related to the post-operative cardiac surgical patient.

Thirty-five post-operative cardiac patients, with pulmonary artery catheters insitu, were prospectively enrolled in this correlational study. All subjects underwent repositioning between the supine and both the left and right 60° lateral position on two occasions each, once while being mechanically ventilated and once while breathing spontaneously. Pulmonary artery pressure measurements, including Pulmonary Artery Systolic, Diastolic, Mean and Capillary Wedge Pressure, were recorded prior to, two minutes following and ten minutes following repositioning. For each subject a surface landmark was identified which corresponded with the mid-point of the thorax in each of the left and right 60° lateral position.

(iii)

Results showed that the dependent mid-clavicular line was the most frequent surface landmark for the zero-point (83% and 74% left and right respectively).

Following change of position, pulmonary artery pressure measurements were variable. In the spontaneously breathing subject these differences had resolved and all pulmonary artery pressure measurements were statistically reliable 10 minutes after repositioning. In subjects being mechanically ventilated, despite some differences remaining, the Pulmonary Capillary Wedge Pressure measurement was statistically reliable 10 minutes after repositioning.

This study concludes that clinical practitioners can confidently obtain accurate Pulmonary Capillary Wedge Pressure measurements in both the spontaneously breathing and mechanically ventilated post-operative cardiac surgical patient positioned in either the left or right 60° lateral position.

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: ....

Date: ....

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

I N T R O D U C T I O N

1.1 The Background to the Study

Critical care units have been developed over recent years to provide a comprehensive specialised division of health care. The general purpose of these units is to return critically ill patients to good health while experiencing the least possible complications. Continuous assessment, in many different formats, comprises a large portion of the work carried out in these units towards achieving this purpose.

Haemodynamic monitoring constitutes an essential element of this continuous assessment and includes, among others, pulmonary artery pressure monitoring. Accurate and reliable use of this monitoring not only enables acquisition of diagnostic information regarding the patient's haemodynamic status, in particular his/her left ventricular function, but also allows assessment of the patient's response to therapeutic interventions.

However, the reliability of measuring pulmonary artery pressures while patients are positioned in the lateral position has been questioned since the early use of pulmonary artery catheters (Pace, 1977). Previous work has not yet provided a clear response to this reliability issue (Groom, Frisch & Elliot, 1990; Guenther, Kay, Cheng & Lauer, 1987; Keating, Bolyard, Eichler & Reed 1986; Kennedy, Bryant & Crawford, 1984). An answer to the question of whether pulmonary artery pressure measurements, obtained while the patient is in the lateral position, are reliable will enable protocols to be developed. These protocols will provide

guidance as to specifying whether patients following cardiac surgery can be turned without experiencing compromised haemodynamic monitoring. By facilitating more frequent and lengthier periods of side positioning of patients, improved respiratory function, decreased tissue breakdown and increased periods of sleep for the critically ill patient will be achieved, while minimising nursing time spent moving the patient between the supine and lateral position.

In conclusion, previous studies have failed to accurately confirm the reliability of haemodynamic monitoring with the patient in the lateral position. Consequently, this study was developed to determine whether Pulmonary Artery Systolic (PAS), Pulmonary Artery Diastolic (PAD), Pulmonary Artery Mean (PAM) and Pulmonary Capillary Wedge Pressure (PCWP) measurements taken with the patient in the 60° lateral position accurately reflect those measurements taken when the patient is in the supine position.

1.2   Research Questions

The following research questions were asked:

1.   Which surface reference points reflect the mathematically derived mid-point of the thorax?

2.   Is there a significant difference in PAS, PAD, PAM and PCWP measurements obtained in the 60° lateral position when compared to those measurements obtained in the supine position in patients being mechanically ventilated?

3. Is there a significant difference in PAS, PAD, PAM and PCWP measurements obtained in the 60° lateral position when compared to those measurements obtained in the supine position in patients breathing spontaneously?

4. Is there a significant difference in PAS, PAD, PAM and PCWP measurements obtained in the 60° lateral position when compared to those measurements obtained in the supine position in patients with the pulmonary artery catheter in the right lung?

5. Is there a significant difference in PAS, PAD, PAM and PCWP measurements obtained in the 60° lateral position when compared to those measurements obtained in the supine position in patients with the pulmonary artery catheter in the left lung?

1.3   Operational Definitions

Repositioning of Patients: movement of the patients, either by themselves or with partial or complete assistance, between the supine and the 60° lateral position.

Supine Position: patient positioned on his or her back with one pillow under his or her head and the head of the bed elevated up to 45° as measured by a protractor.

Right and Left Lateral Position: patient positioned 60° on his or her side as measured by protractor between mattress and patient's back at the level of the inferior angle of the scapula. Patients will continue to have one pillow under their head and the head of bed elevated up to 45° as measured by protractor.

Transducer Position:

Supine Position - 4th intercostal space, mid axillary line.

Right and Left Lateral Position - point of mid-thorax at the level of the 4th intercostal space.

CHAPTER TWO

L I T E R A T U R E   R E V I E W

2.1   Introduction

The theoretical background supporting the use of pulmonary artery catheters to obtain both right and left sided heart pressure is well documented in critical care and haemodynamic texts (Oh, 1990; Daily & Schroeder, 1989).

Haemodynamic monitoring allows critical care clinicians, both nursing and medical, to accurately monitor the effect of either fluid or drugs on the patient's cardiovascular system. These interventions are performed in order to maximise the primary function of the cardiovascular system in supplying oxygen and other substrates while removing carbon dioxide and other metabolites from the body (Oh, 1990). Specifically, pulmonary artery catheters provide monitoring of the left heart pressures in addition to the more customary right heart pressures. This is of benefit due to the fact that left ventricular performance ordinarily correlates with overall cardiac function more closely than that of right ventricular performance, particularly in the diseased heart (Daily & Schroeder, 1989). Pulmonary artery pressure monitoring, as a consequence, provides an indication of cardiac function and the severity of dysfunction.

Literature regarding the reliability of pulmonary artery pressure measurements can be grouped into two major classifications. First, earlier work centred around the effect of backrest elevation on pulmonary artery pressure measurement accuracy in the critically ill patient (Prakash,

Parmley, Dikshit, Forrester & Swan, 1973; Chulay & Miller, 1984; Woods & Mansfield, 1976). The consensus among this work has been that there is no clinically significant effect up to 45°. Second, later work has concentrated on the reliability of haemodynamic monitoring with the patient in the lateral position when compared to the supine position. It is this area of literature which presents conflicting results and hence provided the stimulus for this study.

2.2   Reliability of Haemodynamic Monitoring

Among the earliest reported work in this area is a study by Kennedy et al. (1984) as well as another by Guenther et al. (1987) investigating small groups of medical patients being turned from the supine to the 90° right and left lateral position. Both authors found no significant difference in Pulmonary Capillary Wedge Pressure (PCWP). In contrast Lange, Katz, McBride, Moore and Hillis (1988), Nakao et al. (1986) as well as Keating et al. (1986) found statistically significant differences in pulmonary artery pressures between the supine and lateral positions. Lateral positions varied from 45° to 90° throughout the studies.

More recently Groom et al. (1990) studied both medical and surgical intensive care patients being turned from the supine to the 45° right and left lateral positions. Generally surgical patients demonstrated no statistically or clinically significant difference in pulmonary artery pressures while medical patients showed both statistically and clinically significant differences in all parameters measured.

When interpreting previous work it is difficult to compare one study with another. Some studies have small subject numbers (Guenther et al. 1987, n = 12; Keating et al. 1986, n = 20), as well as addressing a specific segment of the critical care population. Additionally, differing patient and transducer positions were used by Groom et al. (1990). Finally, minimal control of the modifying variables of mechanical ventilation and the position of the pulmonary artery catheter tip was provided by Keating et al. (1986) or Guenther et al (1987).

In order to overcome the above difficulties this study has utilised a large sample size of 28 subjects, each of whom had 4 sets of data recorded, resulting in data analysis being performed on 112 sets of data.

In addition, only patients following cardiac surgery were included in the study to answer the above questions in one specific group of patients. This decision has been made following the suggestion of Kennedy et al. (1984), as well as Keating et al. (1986), that lateral pressure measurements may only be accurate in specific sub-groups of the critical care population. Groom et al. (1990) also identified the need for further work to determine the individual patient characteristics that preclude accurate side-lying measurements. Additionally, information regarding the possible modifying variables of mechanical ventilation and position of pulmonary artery catheter tip will assist in defining these patient characteristics.

The time interval between pressure recording and turning of patients has held no uniformity throughout previous work. Keating et al. (1986) questioned whether this lack of uniformity in time intervals influenced the differences obtained in each of the studies.

Consequently the present study was designed to obtain pressure measurements at both 2 and 10 minutes following turning in an attempt to answer this question. It has been assumed that there is a possibility of finding inaccuracy in the measurements obtained at 2 minutes as a result of the physiological stress the patient experiences in being turned to a new position. This possible influence on pressure measurements, if it is going to resolve, should have resolved by 10 minutes after the change in position.

The 60° lateral position has been utilised to provide information regarding pulmonary artery pressure monitoring in a position which has clinical relevance. In the author's experience, the majority of critically ill patients, when positioned in the lateral position assume a side-lying position of approximately 60°. The literature indicates that backrest position up to a height of 45° has no effect on accuracy of pulmonary artery pressure measurements (Prakash et al. 1973; Chulay & Miller 1984; Woods & Mansfield 1976). The patients in this study, when in either lateral position or the supine position, will therefore be positioned with their head between 0° and 45° so as to ensure no recognisable effect on the pressure readings obtained.

Finally, a significant issue discussed by most researchers has been the choice of anatomical landmark to level transducers against when the patient is in the lateral position. The majority of authors have utilised the fourth intercostal space, midsternal line regardless of the extent to which the patient is in the lateral position or in which lateral position the patient is placed (Groom et al. 1990; Kennedy et al. 1984; Guenther et al. 1987; and Keating et al. 1986). Groom and colleagues (1990) also utilised the fourth intercostal space, dependent mid-axillary line in their surgical

group of patients with reasonable accuracy. It is this variation, ranging between midsternal line and dependent mid-axillary line as the basis for transducer levelling, that has prompted the selection of a mathematically derived mid-point of the thorax (see 4.2 - Establishment of Transducer Levelling Position, page 16) rather than an anatomically derived random position as the site against which to level the transducer in this study.

2.3   Research Focus

Previous studies have fallen short of answering the questions raised which relate to reliability of pulmonary artery pressure measurements when obtained with the patient in the lateral position. This study was designed with the intention of answering some of the questions raised by previous researchers as they completed their work. Specifically these questions have been related to the post-operative cardiac surgical patient positioned in both the right and left 60° lateral position who are both mechanically ventilated and spontaneously breathing.

CHAPTER THREE

CONCEPTUAL FRAMEWORK

Sister Callista Roy, in her Adaptation Model, describes a whole person as a function of four subsystems; that of physiological needs, self-concept, role function and interdependence (Riehl & Roy, 1980). It is the first of these, the physiological subsystem, which provides the framework for this study. The specific elements of the physiological subsystem to be assessed in this study include circulation and oxygenation.

The function of these elements of circulation and oxygenation is twofold: firstly, to deliver adequate amounts of oxygenated blood to meet the body's requirements and secondly, to remove the waste products of metabolism (Roy & Roberts, 1981).

Haemodynamic monitoring, a product of the sciences of anatomy, physiology and physics, enables determination of pulmonary artery pressure measurements. These measurements provide an assessment of preload, one of the determinants of cardiac output within a person. Accurate assessment of preload, in conjunction with other aspects of cardiac and respiratory assessment provide an indication of the functions of the integral elements of circulation and oxygenation within the body.

Throughout her adaptation model, Roy emphasises the importance of meticulous assessment of both behaviour and the stimuli which influence that behaviour. This assessment is based on a thorough knowledge of body structure and function (Pearson & Vaughan, 1986). In this instance knowledge of cardiovascular and respiratory physiology permits the nurse to appropriately assess these physiological elements prior to and during

any manipulation to patient management. In keeping with Roy's guidelines, knowledge of the characteristics and values, specifically pulmonary artery pressure measurements, which are displayed in the normal person are necessary. Incorporated into the above knowledge is identification of the conditions under which these values can accurately be obtained. This study was designed to determine whether the alteration of physical posture from the supine to the side-lying position in association with the altered transducer level, results in inaccuracies when assessing pulmonary artery pressure measurements (see Figure 1).

Physical Stimulus of
Position Change

Physical
Stimulus
of
Mechanical
versus
Spontaneous
Ventilation

ACCURATE DETERMINATION
OF
PULMONARY ARTERY PRESSURE
MEASUREMENTS

ACCURATE ASSESSMENT
OF
CIRCULATION AND OXYGENATION

Physical
Stimulus
of
Pulmonary
Artery
Catheter
Tip
Position

Physical Stimulus of
Transducer Levelling Position
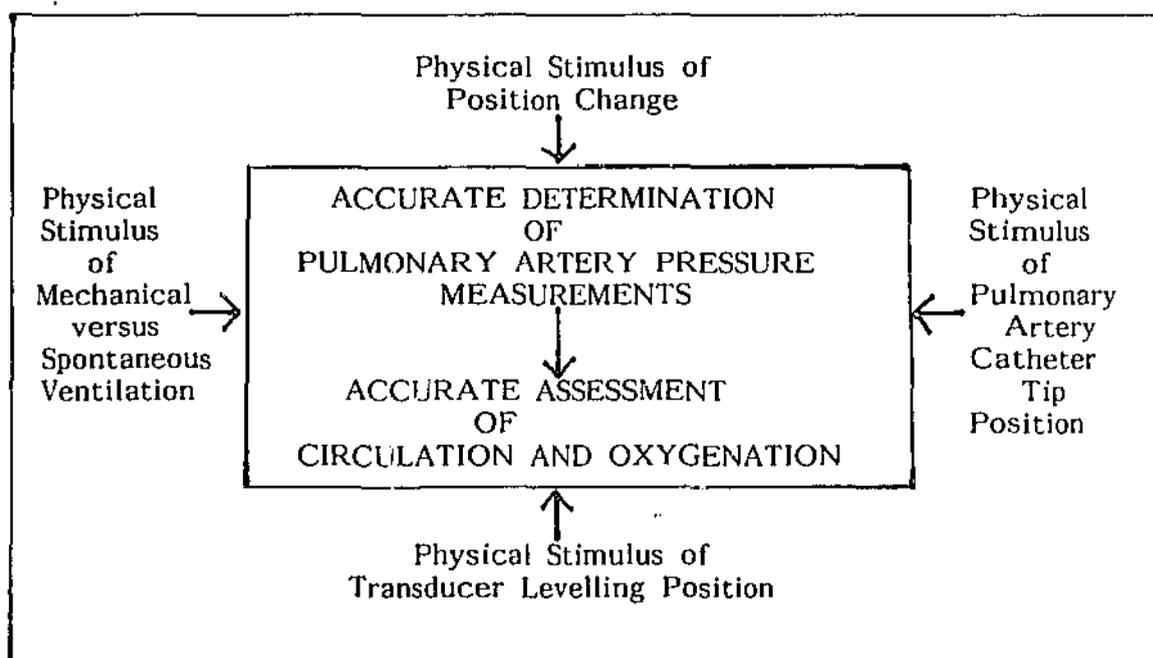
Figure 1:   Application of Roy's Adaptation Model to the Effect of
Position Change on Accuracy of Pulmonary Artery
Pressure Measurements

Contextual stimuli which potentially have an effect on the accuracy of pulmonary artery pressure measurements obtained include mechanical ventilation versus spontaneous breathing and the position of the pulmonary artery catheter tip in either the dependent or non-dependent lung (Figure 1).

Following determination of whether this stimulus of position change does result in inaccurate pulmonary artery pressure measurements, either of two options in manipulation of patient care may then be available to the nurse. The first of these options is to cause the stimulus of position change less frequently and for shorter periods of time to facilitate recording of pressure measurements in only the supine position. Alternatively, modification of the technique used to obtain pulmonary artery pressure measurements, for example alteration of the transducer levelling position, to minimise the effect of the stimulus may be suitable. Utilising either option the goal of patient care in this situation is to minimise the behavioural change in the physiological subsystem which the external stimuli of position change results in, to enable acquisition of accurate pulmonary artery pressure measurements.

Precise pulmonary artery pressure monitoring allows the critical care nurse to perform accurate assessment of one aspect of the patient's condition and assess changes to it as a result of varying stimuli. The Roy Adaptation Model allows for emphasis on and prioritisation within the physiological subsystem, while also providing for assessment of the three remaining subsystems of which a whole person is composed. Additionally, Roy points out that this model is particularly suited to the clinical settings which are characterised by rapid change; for example the Cardiothoracic Intensive Care Unit (Hamner, 1989).

Haemodynamic monitoring is one of the many integral aspects of assessment of the critically ill patient which enable the nurse to fulfil their professional role as an accountable, autonomous practitioner.

CHAPTER FOUR

M E T H O D O L O G Y

4.1 Subjects

The subjects utilised in this prospective correlational study were patients in the Cardiothoracic Intensive Care Unit of a large teaching hospital in Tasmania. All patients who had a balloon-tipped pulmonary artery catheter (American Edwards Laboratories - 93A-131H-7F or Biosensors International - TD1704H) in situ were eligible. Thirty-five subjects were admitted to the study by means of convenience sampling in association with the specified inclusion (Table 1) and exclusion (Table 2) criteria.

Table 1: INCLUSION CRITERIA

1. Pulmonary Artery catheter insitu for general monitoring purposes

2. Subjects post Cardiac Surgery:

    - Coronary Artery Bypass Grafting

    - Valve Repair/Replacement

    - Atrial/Ventricular Septal Defect Repair

Table 2: EXCLUSION CRITERIA

1. Inconclusive Pulmonary Artery or Pulmonary Capillary Wedge recording.

2. Repositioning of patients taking greater than five minutes.

3. Monitoring equipment other than those models stated.

4. Contraindications/inability to reposition patient in either lateral position.

5. Changes in patient treatment required in the time period between the first and third pressure recordings.

Of the 35 subjects studied, 7 were excluded from analysis of Research Questions 2 to 5 on all occasions. They were excluded from the study for the reasons of non-attainment of four sets of complete data (4 subjects), lack of co-operation by the subject in remaining in the lateral position (1 subject), a ruptured pulmonary artery catheter balloon preventing further sets of data being obtained (1 subject) and the subject experiencing severe pleural pain while lying in the lateral position which had the effect of abnormally elevating his pulmonary artery pressures by 10 to 20 millimetres of mercury (mmHg) (1 subject).

However, the data from all subjects, including those excluded for the above reasons, were utilised in answering Question 1 regarding which surface landmarks reflected the mid-point of the thorax.

No effort was made to control for age (except that all subjects were adult), sex, or primary diagnoses other than all patients being in the acute post-operative stage following cardiac surgery (Table 3).

Table 3: PATIENT OPERATIONS

Diagnoses	No. of Patients	% of Patients
Coronary Artery Bypass Grafting	28	80.0%
Valve Repair/Replacement	7	20.0%

Permission to conduct this study was obtained from both the Research and Ethics Committee of the School of Nursing, Edith Cowan University, as well as Nursing Executive and the Ethics Committee within the Royal

Hobart Hospital. Additionally, both the Director of the Cardiothoracic Unit and the Director of Cardiac Anaesthesia gave permission for the study to take place. Individual subjects were not approached for permission during data collection as the alteration of position and the recording of pulmonary artery pressure measurements constituted routine management in this patient population. In order to preserve confidentiality the subject's name and unit record number was recorded only on the subject key.

4.2 Establishment of Transducer Levelling Position

In order to establish an accurate, reliable, haemodynamic monitoring system it is necessary to identify to the system a point or pressure which is to be recognised as zero. All pressures recorded by the system are then measured in comparison to this known zero. Due to the previous variations in zero points used with the patients in the lateral position (see page 8) it was decided for the purpose of this study to utilise a mathematically derived, rather than anatomically derived, point within the thorax. Use of this technique meant the zero-point could be consistently identified despite variations in individual patients and their posture. Additionally, the author held the belief that the mathematically derived zero-point would vary by limited distances between individuals.

Transducer Levelling in the Supine Position

The point of the mid-thorax has been determined by placing the open end of tubing from each of 2 transducers to each lateral aspect of the subject's thorax in the fourth intercostal space, midway between the anterior and posterior thoracic surfaces (Figure 2). While the subject was in the supine position, with the transducers open to the atmosphere, both transducers read zero and identified the appropriate level of the

monitoring transducer. This also confirmed that the open ends of tubing attached to the subject's thorax were in the same position.
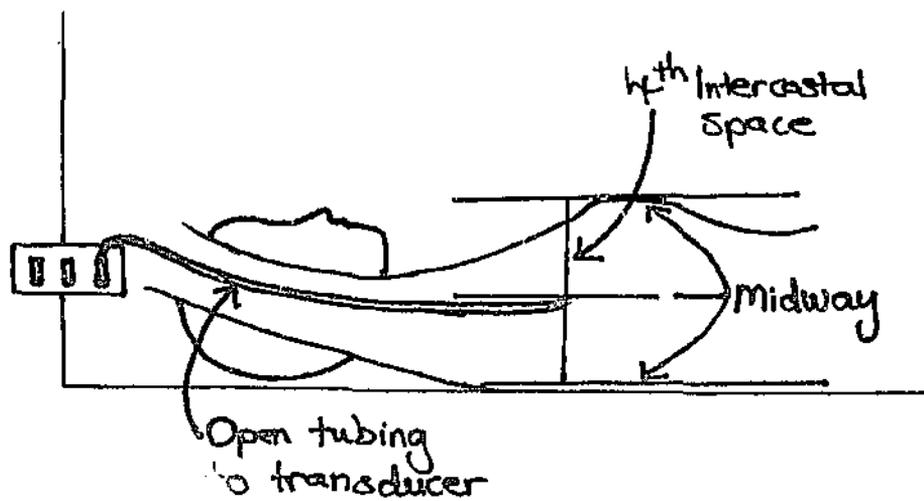
Figure 2:   TRANSDUCER LEVELLING IN THE SUPINE POSITION
(Adapted from Kennedy et al., 1984, Figure 3)

Transducer Levelling in the Lateral Position

The subject was then placed in the 60° lateral position and the height of the transducers realigned so that they each read the same absolute value; for example 9mmHg, with the upper tubing being negative (-9mmHg) and the lower tubing being positive (+9mmHg). This transducer position then identified the mid-point of the thorax and provided the zero point for obtaining the pulmonary artery pressure measurements (Figure 3). On each subject it was then assessed as to which surface landmark this position corresponded with. This landmark was recorded on the data collection forms and marked on the subject's thorax with washable ink for utilisation at further data collection times to ensure consistency in transducer positions.
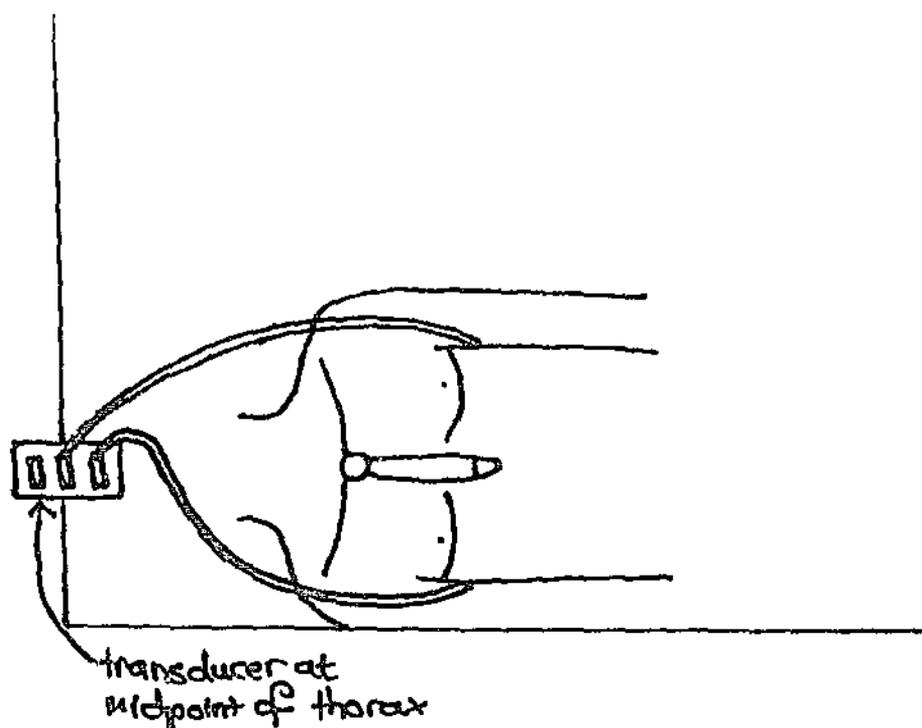
Figure 3:   TRANSDUCER LEVELLING IN THE LATERAL POSITION
(Adapted from Kennedy et al., 1984, Figure 2)

4.3   Instruments

The instruments used to measure pulmonary artery pressures in the subjects consisted of the Siemens Sirecust 1281 physiologic monitor. This system has a documented zero accuracy of ± 12.6 microvolts (± 0.48 mmHg) maximum, with zero drift of the pressure monitoring cartridge compensated for by means of the software autozero (Siemens Operational Manual, 1988). A disposable pressure monitoring transducer and continuous flush device (Carlin Medical Supply P/L, model number CMS-211) was used. Random assessment of fifty percent of these systems demonstrated an observable drift of less than 1 mmHg over twenty-four hours. The system was rezeroed immediately prior to each set of data collection and following each readjustment of transducer level on each subject.

4.4   Procedure

All subjects underwent repositioning between the supine and both the right and left 60° lateral position on 2 occasions each, once while receiving mechanical ventilation and once while breathing spontaneously. Four sets of data were obtained from each subject. Subjects on whom less than 4 sets of data was obtained were removed from the study in order to prevent bias in the results. The timing of repositioning of the subjects was dictated by the subject's condition and by the nurse co-ordinating the care of the subject.

Pressure recordings were obtained 2 minutes prior to, 2 minutes following and 10 minutes following repositioning of the subject. Pressure recordings were obtained following a standard protocol as outlined in Table 4.

Table 4: OUTLINE OF PROTOCOL FOR RECORDING OF PULMONARY ARTERY PRESSURE MEASUREMENTS

1. Check position of patient is within guidelines of the study.

2. Transducer to be levelled to respective position.

3. Assess and record the surface landmark to which the mid-point of the thorax corresponds in the lateral position.

4. Rezero monitoring system prior to obtaining pressure recording.

5. Assess and record Pulmonary Artery Systolic, Diastolic and Mean Pressures at end expiration.

6. Inflate Pulmonary Artery balloon and obtain Pulmonary Capillary Wedge Pressure at end expiration.

7. Ensure Pulmonary Artery trace has returned to the unwedged position.

(For full protocol see Appendix A)

Where possible, the subject received no changes of treatment during the time period between the first and third pressure recordings. If alterations to current treatment were required for optimisation of subject condition the set of data affected was removed from the study.

Correct position of the catheter tip was confirmed radiologically on a routine post-operative chest x-ray and by a correctly identifiable pulmonary artery waveform. Additional information obtained from the chest x-ray was the position of the catheter in either the left or the right lung.

Data collection was performed by the author and 2 other data collectors over an 8 week period. Training took place prior to the pilot study to ensure the principles of patient positioning and pressure measurement were the same between each of the data collectors. Inter-rater reliability was

assessed by means of correlational analysis of 8 sets of data obtained from subjects independently by 2 data collectors on each occasion. These sets of data were obtained within 1 minute of each other to minimise physiologic variation. Measurements obtained by Data Collector 1 were compared individually in relationship to those measurements obtained by the author. As a separate correlational analysis measurements obtained by Data Collector 2 were compared in relation to those measurements obtained by the author. Inter-rater reliability was assessed immediately prior to beginning pilot study data collection and at 4 week intervals throughout data collection.

Inter-rater reliability was analysed using a paired Student's t-test. All analysis demonstrated no significant difference between data collectors with the exception of Pulmonary Artery Mean pressure measurements obtained by the author and the first data collector prior to commencement of data collection (Table 5). In this instance, a statistically significant 'p' value of 0.02 was obtained. No significant difference existed in pressure measurements assessed for inter-rater reliability throughout the study (Table 6).

The statistically significant difference in the Pulmonary Artery Mean Pressure obtained between the author and Data Collector 1 was tolerated in the study for 2 reasons, the first of which concerned the actual data collection. Although not anticipated it was found that collection of an entire set of data was always performed by the same data collector rather than differing data collectors as a result of the shifts that each data collector was rostered on. Consequently at no time was data which had been obtained by one data collector analysed in comparison to that obtained by another data collector.

Table 5: INTER-RATER RELIABILITY PRIOR TO DATA COLLECTION

Author/Data Collector 1	Level of Significance
Pulmonary Artery Systolic Pressure	p = 0.06
Pulmonary Artery Diastolic Pressure	p = 0.14
Pulmonary Artery Mean Pressure	p = 0.02*
Pulmonary Capillary Wedge Pressure	p = 0.34

Author/Data Collector 2	Level of Significance
Pulmonary Artery Systolic Pressure	p = 0.36
Pulmonary Artery Diastolic Pressure	p = 0.08
Pulmonary Artery Mean Pressure	p = 0.26
Pulmonary Capillary Wedge Pressure	p = 0.30

* $P < 0.05$

Table 6: INTER-RATER RELIABILITY THROUGHOUT STUDY

Author/Data Collector 1	Level of Significance
Pulmonary Artery Systolic Pressure	p = 0.54
Pulmonary Artery Diastolic Pressure	p = 0.40
Pulmonary Artery Mean Pressure	p = 0.59
Pulmonary Capillary Wedge Pressure	p = 0.22

Author/Data Collector 2	Level of Significance
Pulmonary Artery Systolic Pressure	p = 0.70
Pulmonary Artery Diastolic Pressure	p = 0.76
Pulmonary Artery Mean Pressure	p = 0.44
Pulmonary Capillary Wedge Pressure	p = 0.52

* $P < 0.05$

The second reason for tolerating this level of correlation was that it represented a difference of only 1.3 mmHg, an amount which is probably clinically insignificant in all adult cardiac surgical patients when considering pulmonary artery pressure measurements.

Data collection followed the format located in Appendices B and C. Patient name and unit record number were documented in the event of requiring further information for modifying variable analysis. This was recorded only on the subject key to preserve confidentiality (Appendix D).

The pilot study included 5 subjects, although the data from only 4 subjects (16 sets of data) was analysed due to being unable to obtain 4 sets of data from the fifth subject.

Analysis of data collected from these subjects demonstrated that each of the research questions asked in this study would be able to be answered using the proposed format. The technique of turning the subjects and obtaining the data was practical within the clinical situation and the patients tolerated the 60° lateral position well.

Following the pilot study, there was no change required to either the format or the data to be collected. Consequently, the study was continued and the subjects from the pilot study were included as the first 4 subjects in the study.

4.5 Data Analysis

Data analysis consisted of a measurement of frequency distribution of each of the surface landmarks identified by the data collectors in order to answer Research Question 1 determining the reference point which reflects the mathematically derived mid point of the thorax. The Statistical Analysis System (SAS, Release 6.03) was used to analyse data in order to answer Research Questions 2 to 5. Specifically, repeated measures ANOVA was used to analyse the significance of differences for each subject between PAS, PAD, PAM and PCWP measurements. These

measurements were obtained at each of 2 minutes and 10 minutes following repositioning in the left and right 60° lateral position and compared to those pressure measurements obtained with the patient in the supine position.

The above analysis was repeated for each of the remaining research questions, on each occasion assessing the pressure measurement differences of a specific sub-group of the study population. For all analysis $P < 0.05$ was considered statistically significant.

CHAPTER FIVE

R E S U L T S

5.1 Surface Landmarks Representing Mid-Point of the Thorax

The mid-point of the thorax corresponded to a maximum of four different surface landmarks in each of the left and right 60° lateral positions. These surface landmarks ranged from the sternal border on the dependent side at the level of the fourth intercostal space, to the anterior axillary line on the dependent side of the subject's thorax at the level of the fourth intercostal space (Figure 4). The frequency of these positions is documented in Tables 7 and 8.
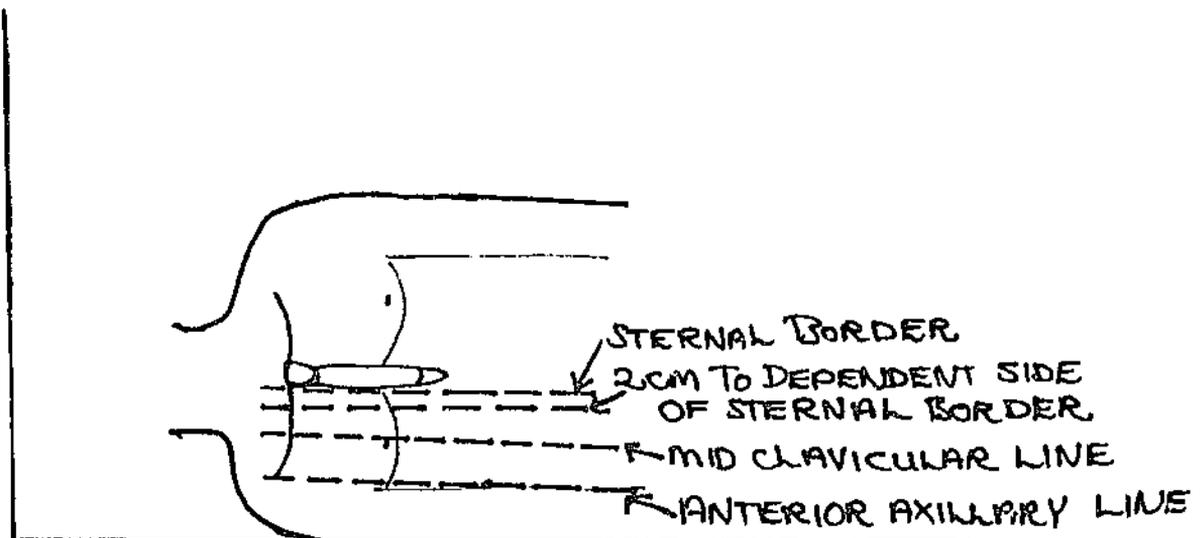
Figure 4: SURFACE LANDMARKS CORRESPONDING TO THE MID-POINT OF THE THORAX

Table 7: SURFACE LANDMARK OF THE MID-POINT OF THE THORAX
LEFT LATERAL POSITION

Anatomical Landmark	No. of subjects	% of subjects
Mid-clavicular line	29	83
2cm left of sternal border	4	11
Left anterior axillary line	2	6

Table 8: SURFACE LANDMARK OF THE MID-POINT OF THE THORAX
RIGHT LATERAL POSITION

Anatomical Landmark	No. of subjects	% of subjects
Mid-clavicular line	26	74
2cm right of sternal border	5	14
Right anterior axillary line	3	9
Right sternal border	1	3

From the above information it should be noted that the use of the mid-clavicular line as the zero point for pulmonary artery pressure monitoring transducers will accurately reflect the mid point of the thorax in 83% and 74% of patients in their left and right 60° lateral positions respectively.

Also noteworthy is the fact that in a further 11% and 14% of subjects in each of the left and right 60° lateral positions respectively, the mid point of the thorax corresponded to a surface landmark in the region of 2cms to the dependent side of the sternal border. This represents a variation in transducer height of approximately 3cms from the mid-clavicular line, a distance which would produce an inaccuracy of 2.2 mmHg.

5.2 Pulmonary Artery Pressure Measurements Related to Ventilation

Pulmonary Artery Pressure measurements varied significantly between the supine and the 60° right and left lateral positions on specific occasions.

Generally this variation followed a predictable pattern which will facilitate incorporation of the findings into clinical practice within the critical care environment.

When the data were analysed in order to answer Research Questions 2 and 3 concerning the influence of ventilation on the differences in pressure measurements, the findings were specific.

Subjects as they were breathing spontaneously, demonstrated statistically significant differences in most pressure measurements obtained following repositioning in either the left or right 60° lateral position when compared to those pressure measurements obtained with the subject in the supine position (Table 9). Further analysis showed this difference to be present 2 minutes following lateral repositioning. This difference had resolved 10 minutes after repositioning (Table 10).

Table 9: PULMONARY ARTERY PRESSURE MEASUREMENTS
SPONTANEOUSLY BREATHING SUBJECTS
n = 28

Pressure	Lateral Position	Supine	2 Mins	10 Mins	F
PAS	Left	34.36	38.75	35.57	13.42*
PAD	Left	15.25	16.39	14.57	8.78*
PAM	Left	23.04	25.54	23.32	11.07*
PCWP	Left	14.89	16.25	14.57	10.27*
PAS	Right	32.58	36.86	34.75	10.21*
PAD	Right	15.11	16.07	15.11	3.14
PAM	Right	22.93	24.54	23.21	7.18*
PCWP	Right	14.93	16.82	15.29	7.25*

* $P < 0.05$

Table 10: TIME ANALYSIS: PULMONARY ARTERY PRESSURE
MEASUREMENTS - SPONTANEOUSLY BREATHING SUBJECTS
n = 28

Pressure	Lateral Position	F Supine - 2 mins.	F Supine - 10 mins.
PAS	Left	17.91*	2.96
PAD	Left	4.27*	2.80
PAM	Left	12.60*	0.28
PCWP	Left	7.89*	0.89
PAS	Right	14.03*	3.36
PAM	Right	9.63*	0.41
PCWP	Right	12.27*	0.00

* P < 0.05

During mechanical ventilation subjects did not demonstrate the same uniformity (Table 11). PAS pressure measurements obtained in the 60° left lateral position 2 minutes following repositioning demonstrated a statistically significant difference when compared to those pressure measurements obtained in the supine position. This difference had resolved by 10 minutes following repositioning of the subject (Table 12). Despite PCWP measurements obtained in the lateral position showing a significant difference when compared to the supine position (Table 11) this difference was not significant when individual analysis at each of 2 and 10 minutes was carried out (Table 12). No other pressure measurements obtained from the mechanically ventilated subjects positioned in the 60° left lateral position demonstrated significant differences when compared to those pressure measurements obtained in the supine position (Table 11).

Table 11: PULMONARY ARTERY PRESSURE MEASUREMENTS
MECHANICALLY VENTILATED SUBJECTS
n = 28

Pressure	Lateral Position	Supine	2 Mins	10 mins	F
PAS	Left	29.64	32.29	29.75	7.44*
PAD	Left	14.57	14.57	14.14	0.32
PAM	Left	21.64	22.43	20.93	2.22
PCWP	Left	11.07	10.61	9.75	3.33*
PAS	Right	30.61	32.14	29.18	6.74*
PAD	Right	15.00	15.29	13.93	7.30*
PAM	Right	21.29	22.54	20.36	10.86*
PCWP	Right	10.43	10.79	9.71	3.53*

* P $<$ 0.05 level

Table 12: TIME ANALYSIS: PULMONARY ARTERY PRESSURE
MEASUREMENTS – MECHANICALLY VENTILATED SUBJECTS
n = 28

Pressure	Lateral Position	F Supine – 2 mins.	F Supine – 10 mins
PAS	Left	8.65*	0.02
PCWP	Left	0.87	4.10
PAS	Right	2.25	6.35*
PAD	Right	0.62	7.62*
PAM	Right	6.24*	4.60*
PCWP	Right	0.54	3.07

* P $<$ 0.05

Mechanically ventilated subjects who were repositioned in the 60$^{\text{o}}$ right lateral position demonstrated pressure differences varying from the above trends. PAS and PAD pressure measurements demonstrated no significant difference 2 minutes following repositioning. By 10 minutes following repositioning to the lateral position a statistically significant difference had developed. PAM pressure measurements obtained were statistically significant at both the 2 and 10 minute interval, while PCWP measurements were not significant at either the 2 or 10 minute intervals (Table 12).

5.3   Influence of Position of Pulmonary Artery Catheter Tip

Research Questions 4 and 5 explored the possibility that the position of the pulmonary artery catheter, in either the dependent or non-dependent lung, exerted an influence on the differences experienced in pulmonary artery pressure measurements between the supine and lateral positions. Results should be interpreted with caution due to the fact that only 4 pulmonary artery catheters were positioned in the left lung, 22 in the right lung, and 2 either indeterminate or varying from the time of one chest x-ray to the next.

Analysis of the larger number of 22 subjects (Research Question 4) with pulmonary artery catheters positioned in the right lung provided similar trends to the analysis of all subjects. In the spontaneously breathing subjects a significant difference existed in pressure measurements obtained in the lateral position when compared to those pressure measurements obtained in the supine position (Table 13). Further analysis showed this difference to exist between those pressure measurements obtained 2 minutes following lateral repositioning when compared to the supine position, and to be resolved 10 minutes following repositioning (Table 14).

Table 13: PULMONARY ARTERY PRESSURE MEASUREMENTS
PULMONARY ARTERY CATHETER POSITIONED IN RIGHT LUNG
n = 22

SPONTANEOUSLY BREATHING

Pressure	Lateral Position	Supine	2 mins.	10 mins	F
PAS	Left	34.36	38.59	35.68	9.14*
PAD	Left	15.23	16.36	14.77	4.86*
PAM	Left	23.14	25.45	23.45	7.53*
PCWP	Left	14.73	16.23	14.36	9.35*
PAS	Right	33.45	36.27	34.32	5.60*
PAD	Right	14.91	15.55	14.73	1.50
PAM	Right	22.68	23.95	22.91	3.88*
PCWP	Right	14.73	16.50	14.36	6.04*

MECHANICALLY VENTILATED

Pressure	Lateral Position	Supine	2 mins.	10 mins	F
PAS	Left	29.23	31.95	29.55	5.36*
PAD	Left	14.55	14.91	14.36	0.34
PAM	Left	21.18	22.50	21.05	2.63
PCWP	Left	10.77	10.73	9.82	2.11
PAS	Right	30.05	32.23	28.91	6.08*
PAD	Right	15.09	15.27	14.09	4.28*
PAM	Right	21.00	22.41	20.36	6.67*
PCWP	Right	10.41	10.41	9.73	1.69

* $P < 0.05$

Table 14: TIME ANALYSIS: PULMONARY ARTERY PRESSURE MEASUREMENTS
PULMONARY ARTERY CATHETER POSITIONED IN RIGHT LUNG
n = 22

SPONTANEOUSLY BREATHING

Pressure	Lateral Position	F Supine - 2 mins	F Supine - 10 mins
PAS	Left	12.67*	3.33
PAD	Left	2.75	0.92
PAM	Left	8.91*	0.33
PCWP	Left	6.77*	1.07
·PAS	Right	7.62*	1.30
PAM	Right	5.18*	0.22
PCWP	Right	8.97*	0.22

MECHANICALLY VENTILATED

Pressure	Lateral Position	F Supine - 2 mins.	F Supine - 10 mins.
PAS	Left	6.11*	0.17
PAS	Right	3.24	2.81
PAD	Right	0.19	4.81*
PAM	Right	5.48*	1.43

* $P < 0.05$

In mechanically ventilated subjects with the pulmonary artery catheter in the right lung, following repositioning to the left lateral position, a statistically significant difference was evident in only the PAS pressure measurement. This difference was present at 2 minutes but had resolved by 10 minutes (Table 14). Following repositioning to the 60° right lateral

position no statistically significant difference was demonstrated in either the PAS or PCWP measurements (Table 14). The PAD pressure measurement demonstrated a statistically significant difference at 10 minutes following repositioning, while the PAM pressure measurement demonstrated a statistically significant difference at 2 minutes, which had resolved by 10 minutes following repositioning (Table 14).

Due to there being only 4 subjects with pulmonary artery catheters positioned in the left lung, no analysis of this sample sub-group was possible. As a result, Research Question 5 was unable to be answered.

CHAPTER SIX

DISCUSSION

6.1   Surface Landmarks

The most frequent surface landmark to correspond to the mid-point of the thorax in both the left and right 60° lateral position (Section 5.1, page 26) was the mid-clavicular line with 29 subjects (83%) in the left lateral position, and 26 subjects (74%) in the right lateral position.

This surface landmark is mid-way between the previously documented landmarks of the midsternum at the level of the fourth intercostal space (Guenther et al. 1987; Keating et al. 1986; Kennedy et al. 1984) and the dependent mid-axillary line at the level of the fourth intercostal space (Groom et al. 1990). The mid-clavicular line at the level of the fourth intercostal space has not been used as the zero point in any previously published studies which this author could locate. This variation may have resulted because previous authors have attempted to identify a surface landmark which corresponded to either the right or left atrium when the patient was in the lateral position. Instead, this author identified a surface landmark with the same zero value in the lateral position as that commonly used in the supine position.

Additionally, acceptance of a variation of 3cm in the height of the transducer, representing 2.2 mmHg pressure, would increase the group of patients in which use of the dependent mid-clavicular line represented the midpoint of the thorax to 33 subjects (94%) and 31 subjects (88%) in the left and right 60° lateral positions respectively. This can be achieved by inclusion of those subjects where the level of the mid-point of the thorax corresponded to the level of a point 2cms to the dependent side of the sternal border in each lateral position. The 2.2 mmHg pressure variation

which this inclusion introduces is probably clinically insignificant in the adult post-operative cardiac population.

Consideration of the remainder of the patients demonstrates a variation between the mid-clavicular line and the mid-point of the thorax of less than 5 cms at all times. This has the potential to result in an inaccuracy in pressure measurements of 3.7 mmHg, an amount which may be clinically significant. It was not possible to identify any special characteristics of this sub-group of up to 10% of the patient population, either pre- or post-testing. However, it is worth noting that haemodynamic parameters should not be taken in isolation, but in association with a concurrent clinical assessment.

In conclusion, in patients lying in the 60° lateral position, the dependent mid-clavicular line adequately reflects the level of the mid-point of the thorax.

6.2   Accuracy of Pulmonary Artery Pressures in the Lateral Position
a) The effect of time on pressure measurements

Analysis of pulmonary artery pressure measurements obtained from the subjects while they were breathing spontaneously and those obtained from the subjects while they were mechanically ventilated provided some significant patterns. When comparing these results to previous literature, it should be noted that this author could not locate any other author's work which studied a specific group of solely post-operative cardiac surgical patients. This patient population has, however, been a portion of the subject numbers in one study (Groom et al. 1990).

Spontaneously breathing subjects demonstrated a statistically significant difference in all pressure measurements 2 minutes following repositioning. This difference had resolved by 10 minutes following repositioning, and was seen in both the left and right 60° lateral positions. This differed from the results of Kennedy et al. (1984) who found no statistically significant difference in PAS, PAD, PAM or PCWP measurements when recorded less than 3 minutes following repositioning in spontaneously breathing subjects. In contrast Lange et al. (1988) allowed 10 minutes to elapse following repositioning of spontaneously breathing subjects and found statistically significant differences in Left Ventricular End Diastolic Pressures. The possible methodological difference in these studies to be responsible for the differing results lies in the lateral zero reference point. Kennedy et al. (1984) used similar techniques to those used for this this study, but referenced the transducers to the mid-sternum at the level of the 4th intercostal space, while Lange et al. (1988) used micromanometers placed directly into specific chambers of the heart to obtain pressure measurements.

The most probable explanation for the significant difference at 2 minutes and resolution by 10 minutes lies in the physiological stress of turning subjects, whether it be by themselves or with assistance. This stress apparently disperses in less than 10 minutes providing the subject is comfortable in the lateral position.

Observation of the pressure measurements obtained in specific subjects who were obviously uncomfortable in the lateral position revealed clinically significant elevation of all pulmonary artery pressure measurements which required longer than 10 minutes to return to a level near to the pressure measurements recorded in the supine control position.

One subject was in fact withdrawn from the study due to severe limiting pleuritic pain preventing him from remaining in the lateral position for 10 minutes. During the time the subject was positioned in the lateral position pressure measurements were greater than 20 mmHg higher than those obtained in the supine position.

Additionally, subjects in this post cardiac surgery sub-group of the critical care population, when breathing spontaneously are more awake and therefore more likely to experience increased stress with significant repositioning than their ventilated, usually more sedated counterparts.

Mechanically ventilated subjects did not demonstrate the same uniformity as those breathing spontaneously throughout all pressure measurement recordings. During repositioning to the 60° left lateral position any statistically significant differences which existed in mechanically ventilated subjects at 2 minutes had resolved by 10 minutes following repositioning.

In contrast this was not always the case with repositioning of mechanically ventilated subjects to the 60° right lateral position. Statistically significant differences in PAS and PAD pressure measurements were apparent 10 minutes following repositioning while significant differences in PAM pressure measurements existed both 2 and 10 minutes following repositioning. However, the PCWP measurement, the most frequently used and heavily relied upon of the pulmonary artery pressure measurements, showed no statistically significant difference at either the 2 or 10 minute period. This author could find no previously published studies which had a population of purely mechanically ventilated subjects with which to compare these results.

An associated factor to have an effect on the pulmonary artery pressure measurements of the subjects is the degree of Positive End Expiratory Pressure (PEEP) which the subject is receiving. Although this was constant for all subjects while they were mechanically ventilated (4 ± 1 cm H20), the subjects received no equivalent Continuous Positive Airways Pressure (CPAP) while breathing spontaneously. It is therefore possible that the presence of PEEP rather than the mode of ventilation exerted an influence on pulmonary artery pressure measurement stability.

In summary, the mode of ventilation appears to have some influence on the accuracy of pulmonary artery pressure measurements. This effect is predominant in the first 2 minutes following repositioning, when the pressure measurement obtained is usually several millimetres of mercury higher than that obtained in the supine position. This difference has almost always resolved once 10 minutes have elapsed. It is questionable whether this influence is due to ventilation or associated factors such as PEEP or the sedation and resultant drowsiness of the subject.

b) The influence of the position of the pulmonary artery catheter tip

As a result of the small number of catheters positioned in the left lung analysis of results to determine whether the position of the pulmonary artery catheter had an effect on the accuracy of the pulmonary artery pressure measurements obtained was of minimal benefit. This analysis examined the effect of the pulmonary artery catheter in either the dependent or the non-dependent lung.

Worthy of note however, was the fact that following exclusion of the subjects with pulmonary artery catheters positioned in the left lung, analysis of mechanically ventilated subjects repositioned in the 60^{0} right

lateral position resulted in a significant difference in only the PAD pressure measurement at 10 minutes (Table 14). This is in contrast to analysis of all mechanically ventilated subjects repositioned in the 60° right lateral position where statistically significant differences were found in PAS, PAD and PAM pressure measurements at 10 minutes (Table 12).

A possible reason for this improved correlation is that subjects with their pulmonary artery catheter positioned in the left lung, when placed in the 60° right lateral position, have their catheter resting in zone one of the lung, an area of decreased blood flow according to West (1979). Removal of the sub-group of subjects with their pulmonary artery catheter in this zone results in decreased differences in the remaining pressure measurements. It was not possible to determine if this trend was apparent in the reverse situation, when repositioning subjects with the pulmonary artery catheter in the left lung into the right lateral position, due to there being only 4 subjects involved. Larger subject numbers, with pulmonary artery catheters positioned in both the left and right lung, would be required to test this explanation.

According to the conceptual framework for this study it is possible to assess the function of the physiological subsystems of circulation and oxygenation with the subject positioned in either the left or right 60° lateral position. Nursing practice need only be modified to the extent that pressure measurements are not obtained prior to the elapse of 10 minutes following repositioning. The contextual stimuli of mode of ventilation and position of the pulmonary artery catheter tip have an influence on the accuracy of this assessment.

6.3   Influencing Variables

Variables which have the possibility of influencing the results in this study do exist. All of the subjects were in the acute post-operative period following cardiac surgery, an interval which is characterised by its potential for instability.

The haemodynamic stability of each individual subject has the possibility of affecting pulmonary artery pressure stability, particularly when considered in conjunction with the use of vasoactive drugs. The most prominent of these drugs include inotropic agents, such as Adrenaline and Dopamine, as well as nitrates such as Sodium Nitroprusside and Glycerol Trinitrate (Whipple et al. 1992). Additional significant drugs frequently used in the post-operative cardiac surgical patient include anti-arrhythmic agents, Angiotensin Converting Enzyme (ACE) Inhibitors, beta blocking agents and diuretic agents. Use of the above categories of drugs was not controlled for or recorded in this study although some of the subjects were receiving one or more of the agents. The specific effect of each of these drug categories on pulmonary artery pressures, particularly in the setting of repositioning of the patient, is not known.

Pathophysiologic factors which potentially have an influence on the subject's pulmonary artery pressure stability include not only the primary disease status of the subjects, but also their current left ventricular function, the presence of severe pulmonary disease and the degree of elevation in their baseline pulmonary artery pressures (Schermer, 1988). It was preferred not to control for these factors in this study, but rather to obtain an answer to the research questions relevant to the entire post-operative cardiac population.

Another aspect of patient management which potentially exerts an influence on pulmonary artery pressure stability is the West zone of the lung in which the pulmonary artery catheter is placed (West, 1979). This varies with each repositioning of the patient, and is difficult to determine due to the need for both an anterior-posterior and lateral chest x-ray to be obtained with the subject in each new position.

6.4 Limitations

Although subjects who required active treatment between the first and third pressure measurement in each set of data were excluded from analysis, it was not possible to determine if smaller changes in pressure measurements, of an insufficient nature to require intervention, were the result of the position change or a condition change. A time interval of 10 minutes is sufficient time for a subject in this population to experience a marked change in condition without the additional factor of a position change. There is no method of measuring or controlling for these changes.

Assessment of the effect of the position of the pulmonary artery catheter tip in the lung was open to possible inaccuracy as a result of the possibility of movement of the catheter tip between the time of chest x-ray and the measurement of pulmonary artery pressures. This interval ranged from approximately 1 to 24 hours. Catheter manipulation, in the event of a non-clearly defined Pulmonary Capillary Wedge trace, was allowed.

The small number of subjects suitable for inclusion in this study presented a minor limitation given the time frame available. With the availability of further time or subjects from multiple centres, this aspect would not be a problem.

6.5 Implications for Nursing Practice

The findings of this study will allow nurses caring for post-operative cardiac surgical patients to confidently obtain accurate pulmonary artery pressure measurements from the spontaneously breathing patient who is positioned in either the left or right 60° lateral position. Reliable pressure measurements can be obtained providing 10 minutes have elapsed following the time of repositioning.

Mechanically ventilated patients require more specific management. While they are positioned in the 60° *left* lateral position accurate pulmonary artery pressure measurements can be obtained providing 10 minutes have elapsed following repositioning. However, while positioning a mechanically ventilated patient in the 60° *right* lateral position an accurate PCWP is the only pulmonary artery pressure measurement which can be obtained confidently.

Nurses will be aware that pulmonary artery pressure measurements obtained prior to the elapse of the first 10 minutes have the risk of being inappropriately elevated, presumably due to the physiological stress of repositioning which the patient experiences.

The above knowledge will enable promotion of increased periods of sleep in patients by facilitating lengthier side positioning. Secondly, this will result in improved respiratory function by allowing enhancement of ventilation/perfusion ratios. Thirdly, the post-operative cardiac surgical patient will experience decreased tissue breakdown as a result of the diminished need for long periods of time in the supine position. Finally, with the decrease in unnecessary utilisation of nursing and paramedical time spent repositioning patients to the supine position for regular

pressure measurements, the time available for other nursing management will be increased.

6.6 Recommendations for Further Research

This study has achieved the objective of identifying whether accurate pulmonary artery pressure measurements can be obtained in the post-operative cardiac surgical sub-group of the critical care patient population.

There still remain, however, several related areas in which unanswered questions exist. Although this study has assisted in providing information regarding the post-operative cardiac surgical sub-group of patients it has not studied other sub-groups of the critical care population. There remains a need to identify the physiologic and pathophysiologic characteristics which preclude the critical care nurse from obtaining accurate pulmonary artery pressure measurements with the subject in the 60° lateral position.

In addition to identification of the physiologic and pathophysiologic variables, there is the need to identify the specific management variables, such as the use of vasoactive agents and levels of Positive End Expiratory Pressure (PEEP) utilised and position of the pulmonary artery catheter tip, which exert an effect on the accuracy of pulmonary artery pressure measurements obtained in the 60° lateral position.

To enable the above variables to be controlled for it is suggested that a larger sample size be studied. To overcome possible problems in obtaining sufficient subject numbers it is also recommended that more than 3 data collectors be involved. This would alleviate difficulties caused by shift work rosters, as well as time frames related to patient management such

as the length of time between commencement of spontaneous breathing and removal of the pulmonary artery catheter.

The use of the dependent mid-clavicular line at the level of the fourth intercostal space provides accurate pulmonary artery pressure measurements in the majority of post-operative cardiac surgical patients. Identification of the thoracic anatomical features which characterise the small proportion of patients in whom use of the mid-clavicular line as the zero point does not provide accurate pulmonary artery pressure measurements with the patients in the lateral position would provide greater confidence for clinical practitioners.

A final area which, although difficult to assess, may provide some revealing information is measurement of the variation between nurse practitioners in their subjective determination of the position of the mid-clavicular line at the level of the fourth intercostal space in a range of subjects. Conceivably, this variation may be greater than the variation between surface landmarks representing the mid-point of the thorax in a cross-section of subjects.

REFERENCES

Chulay, M., & Miller, T. (1984). The effect of backrest elevation on pulmonary artery and pulmonary capillary wedge pressures in patients after cardiac surgery. Heart & Lung, 13(2), 138-140.

Daily, E.K,. & Schroeder, J.S. (1989). Techniques in Bedside Hemodynamic Monitoring. (4th ed.) St. Louis: The C.V. Mosby Company.

Groom, L., Frisch, S.R., & Elliott, M. (1990). Reproducibility and accuracy of pulmonary artery pressure measurement in supine and lateral positions. Heart & Lung, 19(2), 147-151.

Guenther, N.R., Kay, J., Cheng, E.Y., & Lauer, K.K. (1987). Comparing pulmonary artery catheter measurements in the supine, prone and lateral positions (abstract). Critical Care Medicine, 15(4), 383.

Hamner, J.B. (1989). Applying the Roy Adaptation Model to the CCU. Critical Care Nurse, 9(3), 72-81.

Keating, D., Bolyard, K., Eichler, E., & Reed, J. (1986). Effect of sidelying positions on pulmonary artery pressures. Heart & Lung, 15(6), 605-610.

Kennedy, G.T., Bryant, A., & Crawford, M.H. (1984). The effects of lateral body positioning on measurements of pulmonary artery and pulmonary artery wedge pressures. Heart & Lung, 13(2), 155-158.

Lange, R.A., Katz, J., McBride, W., Moore, D.M., & Hillis, L.D. (1988). Effects of supine and lateral positions on cardiac output and intracardiac pressures. The American Journal of Cardiology, 62, 330-333.

Nakao, S., Come, P.C., Miller, M.J., Momomura, S., Sahagian, P., Ransil, B.J., & Grossman, W. (1986). Effects of supine and lateral positions on cardiac output and intracardiac pressures: an experimental study. Circulation, 73(3), 579-585.

Oh, T.E. (Ed.). (1990). Intensive Care Manual (3rd ed.). Sydney: Butterworths.

Pace, N.L. (1977). A critique of flow-directed pulmonary arterial catheterization. Anesthesiology, 47, 455-465.

Pearson, A., & Vaughan, B. (1986). Nursing Models for Practice. London: Heinemann Nursing.

Prakash, R., Parmley, W.W., Dikshit, K., Forrester, J., & Swan, H.J.C. (1973). Hemodynamic effects of postural changes in patients with acute myocardial infarction. Chest, 64(1), 7-9.

Riehl, J.P. & Roy, Sr. C. (Eds.) (1980). Conceptual Models for Nursing Practice. (2nd ed.). New York: Appleton-Century-Crofts.

Roy, Sr. C., & Roberts, S.L. (1981). Theory Construction in Nursing: An Adaptation Model. Englewood Cliffs, N.J: Prentice-Hall

Schermer, L. (1988). Physiologic and technical variables affecting hemodynamic measurements. Critical Care Nurse, 8(2), 33-42.

Siemen's Operational Manual (1988). Siemens Medical Electronics, Inc., Danvers, U.S.A.

West, J.B. (1979). Respiratory Physiology - the Essentials, (2nd ed.) Baltimore: Williams & Wilkins.

Whipple, J.K., Medicus Bringa, M.A., Schimel, B.A., Jiricka, M.K., Lynch, M.C., Quebberman, E.J.(1992). Selected Vasoactive Drugs: A Readily Available Chart Reference. Critical Care Nurse, 12(3), 23-29.

Woods, S.L., & Mansfield, L.W. (1976). Effect of body position upon pulmonary artery and pulmonary capillary wedge pressures in noncritically ill patients. Heart & Lung, 5(1), 83-90.

BIBLIOGRAPHY

Connors, A.F., McCaffree, D.R., & Gray, B.A. (1983). Evaluation of right-heart catheterization in the critically ill patient without acute myocardial infarction. The New England Journal of Medicine, 308(5), 263-267.

Gassert, C.A. (1990). Reliability and validity of physiologic measurement. Critical Care Nursing Quarterly, 12(4), 17-20.

Lindsey, A.M. (1984). Research for clinical practice: physiological phenomena. Heart & Lung, 13(5), 496-507.

Morris, A.H., Chapman, R.H., & Gardner, R.M., (1984). Frequency of technical problems encountered in the measurement of pulmonary artery wedge pressure. Critical Care Medicine, 12(3), 164-170.

Nemens, E.J., & Woods, S.L. (1982). Normal fluctuations in pulmonary artery and pulmonary capillary wedge pressures in acutely ill patients. Heart & Lung. 11(5), 393-398.

Rajacich, N., Burchard, K.W., Hasan, F.M., & Singh, A.K. (1989). Central venous pressure and pulmonary capillary wedge pressure as estimates of left atrial pressure: effects of positive end-expiratory pressure and catheter tip malposition. Critical Care Medicine, 17(1), 7-11.

Shinn, J.A., Woods, S.L., & Huseby, J.S. (1970). Effect of intermittent positive pressure ventilation upon pulmonary artery and pulmonary capillary wedge pressures in acutely ill patients. Heart & Lung, 8(2), 322-327.

Swan, H.J.C., Ganz, W., Forrester, J., Marcus, H., Diamond, G., & Chonette, D. (1970). Catheterization of the heart in man with use of a flow-directed balloon-tipped catheter. The New England Journal of Medicine, 283(9), 447-451.

APPENDIX A

Protocol for Recording of Pulmonary Artery Pressure Measurements

1. Check position of patient is within guidelines of the study:

   - Supine Position: lying on back, one pillow under head,

     head elevated 0-45°.

   - Lateral Positions: 60° on side, angle measured by protractor

     between mattress and patient's back at the level

     of the inferior angle of the scapula, one pillow

     under head, head elevated 0-45°.

   - Bed base not tilted head up or down.

2. Transducer to be levelled to respective position using a flexible

   spirit level where appropriate.

   Supine Position: 4th Intercostal Space, Mid Axillary Line.

   Lateral Positions: Mid point of the thorax as described on page

   18.

3. Assess and record the surface landmark to which the mid-point

   of the thorax corresponds to in the lateral position.

4. Rezero monitoring system prior to obtaining pressure recording.

5. Obtain Pulmonary Artery Systolic, Diastolic and Mean pressures at

   end expiration.

6. Inflate pulmonary artery balloon and obtain Pulmonary Capillary

   Wedge Pressure at end expiration.

   NB: If respiratory swing is present in pressure tracing a frozen

   trace and cursor (Siemens Sirecust 1281 monitor) is to be utilised

   to identify end expiration.

7. Ensure Pulmonary Artery trace has returned to the unwedged

   position.

APPENDIX B

Subject Number - Name Key

Subject Number	Subject UR Number	Subject Name

APPENDIX C

GENERAL DATA

SUBJECT NUMBER: _____

PRIMARY REASON FOR ADMISSION TO CICU:_____

WHICH LUNG IS 'SWAN GANZ' CATHETER IN ON CHÈST X-RAY?

DATE	LUNG

SURFACE LANDMARK TO WHICH MID-POINT OF THORAX CORRESPONDS:

LEFT LATERAL POSITION_____

RIGHT LATERAL POSITION_____

APPENDIX D

SPECIFIC DATA

SUBJECT NUMBER: _____

MECHANICAL VENTILATION: -   YES   [   ]

NO   [   ]

PEEP/CPAP: -   0 cm   [   ]

5 cm   [   ]

7.5 cm   [   ]

10 cm   [   ]

Higher   [   ]   Specify Amount:_____

MEASUREMENT RECORDINGS:

	2 Mins Prior	2 Mins After	10 Mins After
POSITION			
PAS			
PAD			
PAM			
PCWP			