

LEAD PLACEMENT FOR CONTINUOUS ELECTROCARDIOGRAPHIC MONITORING

by

Sue Ann Prato

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SIGNED: \_\_\_\_\_

*Sue Ann Prato*

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

*Karen S. Sechrist*

KAREN S. SECHRIST

Assistant Professor of Nursing

*August 8, 1974*

Date

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## ABSTRACT

A comparative study was conducted in an effort to arrive at the lead placement pattern which provided the most readable P waves and QRS complexes for continuous electrocardiographic monitoring. Leads I<sub>1</sub>, CM<sub>5</sub> and MCL<sub>1</sub> were applied to each of 50 patients and the EKG strips obtained measured with an Abbott EKG ruler for height of the QRS complexes. The paper itself was used to measure the P waves.

The results were compared with seven other variables, i.e., age, sex, height, weight, and whether the patient was currently taking Digoxin, Pronestyl, and/or Quinidine. The data was compiled with a complete statistical analysis run by computer to evaluate the QRS complexes. The analysis showed no positive correlations with these variables. In comparing each of the leads with each of the other two, the differences in QRS amplitude were significant at the 0.05 level. In evaluating the P waves, an average of their height in each lead was computed. Although no lead performed consistently, Lead I<sub>1</sub> gave the tallest average P waves and QRS complexes, Lead CM<sub>5</sub> ranked second, and Lead MCL<sub>1</sub> ranked third. The computer analysis was corrected for any possible influence of the other variables considered.

## CHAPTER 1

### INTRODUCTION

Coronary artery disease, ranked as the number one cause of death in the United States today, presents a problem of ever-increasing magnitude. More than ten million persons are estimated to suffer from heart disease and in excess of nine hundred thousand persons die each year as a direct result of heart disease (Lewis 1971). Of the one million five Hundred thousand persons who suffer myocardial infarctions each year, about 30 percent of those hospitalized die. "Death is frequently not the inexorable result of extensive myocardial damage but is due to a completely reversible electrical derangement of rhythm" (Lown and Selzer 1968, p. 597). If the rhythm of the heart could be followed at all times during the acute period by electronic means with resuscitative equipment kept nearby, deaths due to arrhythmias might be prevented.

The fact that many arrhythmias are reversible if detected early and treated forms the basis for the effectiveness of Coronary Care Units. Continuous electrocardiographic (EKG) monitoring of patients in the Coronary Care Unit has become an integral part of observation and prophylactic treatment in providing continuous information about the cardiac status. The Coronary Care Unit is a realization of an effort to find more effective means of lowering the mortality rate of myocardial infarctions and increasing the number of successful cardiac

resuscitations. The actual emphasis in the Coronary Care Unit has now shifted from successful resuscitation to prevention of electrical failure of the heart and averting the need for resuscitation. Constant EKG monitoring provides the means for averting or terminating successfully the life-threatening arrhythmia.

The continuous EKG is the single best method of detecting changes in impulse conduction or formation within the heart. The sites of electrode placement determine the amplitude and direction of the EKG write-out and may influence the detection of smaller waves within the complex.

#### Statement of the Problem

Does the MCL<sub>1</sub>, Lead 11 or CM<sub>5</sub> electrode placement pattern give the most readable P waves and QRS complexes?

#### Hypothesis

The MCL<sub>1</sub> placement pattern will provide a significantly greater amplitude of the QRS complex than either the Lead 11 or CM<sub>5</sub> electrode placement patterns.

#### Null Hypothesis

The MCL<sub>1</sub> placement pattern will not provide a significantly greater amplitude of the QRS complex than either Lead 11 or the CM<sub>5</sub> electrode placement pattern.

#### Significance of the Problem

A readable EKG write-out and one of sufficient amplitude that is easily read is vital in making a differential diagnosis between

disturbances of impulse conduction and those of impulse formation. An often encountered problem is one of distinguishing ventricular premature beats from those supraventricular in origin with aberrant conduction. Accurate diagnosis and prompt treatment depend on a readable EKG tracing.

Since nurses are most frequently involved in EKG monitoring, it is important for them to know which lead placement will afford the most readable pattern.

#### Purpose of the Study

By means of a comparative study, the author aimed to arrive at an electrode arrangement pattern that would give the most readable QRS complex pattern when applied as defined.

This study was addressed primarily to Coronary Care Unit nurses who often use their own discretion in placing chest electrodes to obtain the clearest EKG write-outs while leaving those areas of the chest used for emergency defibrillation exposed. This system allowed for a trial and error method of electrode placement with a waste of time on the nurses' part and a needless delay in the evaluation of the patient's cardiac status. In using a non-standardized method of monitoring, a great deal of dysrhythmic information was overlooked (Marriott and Fogg 1970).

#### Theoretical Framework

The normal resting cardiac muscle cell actively maintains an ionic disequilibrium across the cell membrane, with a resting membrane potential of a minus 90 millivolts. The potassium ion is maintained in

greater concentrations inside the cell and the sodium ion in greater concentrations outside of the cell. Following excitement of the cell, depolarization, the situation is reversed, with an influx of sodium into the cell and potassium leaving the cell. The polarity is thus altered with the outside of the cell more negative than the inside by about 20 millivolts. The polarity is soon neutralized, however, with a zero potential restored across the cellular membrane. The depolarized portion of the cell still remains more negative than the resting portion of the cell though, with the potential difference remaining at 90 millivolts. It is this electrical gradient that allows the wave of depolarization to spread throughout the cell and from one muscle cell to the next (Winsor 1968).

The sino-atrial node, a specialized mass of cells in the right atrium, acts as the pacemaker of the heart. The S-A node generates the electrical potentials resulting in the contraction of the myocardium. The sinus maintains the role of pacemaker for the heart solely because its resting membrane potential of a minus 40 millivolts is less than that of other cardiac cells. Consequently, the S-A node generates an electrical potential sooner than other cardiac cells and initiates the cardiac cycle.

The body is a volume conductor acting as an electrolyte solution which allows electrical activity inside the body to be monitored on the body surface. Around 1903, Einthoven (in Blake 1972) designed the method for measuring these potentials, standardizing a lead system for recording electrocardiograms. In establishing this lead system,

Einthoven had several basic assumptions about the electrical properties of the body. Einthoven stated that the heart was a single dipole (a pair of opposite electrical charges) in the center of the body which is a volume conductor. He believed that all tissue cells were of equal conductivity. The shoulders and the symphysis pubis were both considered in the same frontal plane that were of equal distances from each other and the heart (Blake 1972).

"The EKG is a semi-periodic signal recorded from the surface of the body representing the electrical activity of the heart" (Golden, Mauldin and Wolthuis 1970, p. 296). The actual pulse produces a relatively low magnitude signal which must be converted by a transducer to a readable electrical signal. This bioelectric signal can be obtained with reliability from the chest wall. The entire basis for electrocardiography can be rather easily summed up. The electrical forces generated within the heart are transmitted through the body due to its electrolyte properties and can be detected with electrodes on the body surface. The ebb and flow of these electrical forces produce the deflections seen on the galvanometer. The waves are then amplified to make them seen more easily.

If the advancing wave of depolarization is traveling toward an electrode, a positive deflection will be produced on the EKG. By the same token, an electrode behind the advancing wave of depolarization will show a negative deflection. Should an electrode lie perpendicular to the depolarizing wave, the deflection will be either diphasic, or no deflection whatsoever will show on the EKG. The magnitude of the

deflection is dependent on several factors, among them the thickness of the muscle involved, the width of the patient's chest, and the inherent strength of cardiac contraction.

Following depolarization and contraction, the muscle cells are repolarized and return to their original resting state with the restoration of the ionic disequilibrium.

Meltzer (1965, p. 64) states:

The original impulse from the sino-atrial node, the conduction through the heart, the contraction of muscles, and the recovery period can be correlated with the flow of electrical forces at that particular instant. The combined periods of contraction (depolarization) and recovery (repolarization) constitute the cardiac cycle.

Each cardiac cycle is recorded and displayed on the oscilloscope of the cardiac monitor which is basically a fluorescent screen across which a point of light passes. The heart's action causes this point of light to fluctuate either above or below the straight isoelectric line (McKenzie 1969).

The standard 12 lead EKG allows the three dimensional heart to be viewed from 12 different angles. The amplitude of the electrical force recorded is determined by the size of the muscles involved, the angle of the electrode and the distance of the electrode from the muscle. In Coronary Care Units, the continuous EKG tracing is usually recorded on a lead comparable to the standard Lead II. In diagnosing a mechanism, actually any lead may be used as long as the P and the QRS waves can be clearly identified. Physiologically speaking, Leads II and  $MCL_1$  (modified  $V_1$ ) should be the most useful because of their relation to the route of depolarization in most people (Blake 1972).

### Limitations

1. The study was limited to fifty persons including patients in Intensive Care and Coronary Care Units and healthy volunteers.
2. The study was limited to those patients who were not in critical condition and were not being treated for any arrhythmias.
3. The patient population of the study was limited to patients currently under continuous EKG monitoring and who gave their verbal consent to participate.

### Assumptions

1. The patients involved did not have dextracardia, nor any gross abnormality of organ location.
2. Any axis deviation that may have been present did not significantly affect the outcome of the research.
3. Technically, the electrodes were properly applied and were not a variable factor in the results obtained.

### Definitions

1. Lead--"A particular terminal pair (of electrodes) in which a voltage is developed" (Geselowitz 1971, p. 39).
2. Lead II--"The negative electrode is on the right arm, and the positive electrode represents the left leg" (Andreoli et al. 1968, p. 37). The negative electrode was two inches below the right midclavicular line, the positive electrode over the left lower rib margin, and the ground over the lower one-third of the sternum.

3. Lead  $CM_5$ --"Bipolar electrode placement, the positive left arm electrode is at the left fifth intercostal space, the negative right arm electrode at the sternal notch and the ground electrode at the right fifth intercostal space" (Kemp 1973, p. 227).
4. Lead  $MCL_1$ --"The positive electrode is at the fourth right inter-space at the right sternal edge, the negative electrode is placed under the outer one-fourth of the left clavicle. The right shoulder is suitable for the ground" (Marriott and Fogg 1970, p. 104).
5. "The electrocardiogram is a semi-periodic signal recorded from the surface of the body representing the electrical activity of the heart" (Golden et al. 1970, p. 296).
6. QRS amplitude--the algebraic sum of the R and S waves of the electrocardiogram.

## CHAPTER 2

### REVIEW OF LITERATURE

The use of chest leads (modified forms of which are the  $MCL_1$  and  $CM_5$ ) was introduced around 1932 by Wolferth (an American physiologist) and Wood (in Schmidt 1959). EKG's then, as now, were recorded by means of electrodes attached to the patient's skin in various ways or needles inserted subcutaneously. The resultant EKG is an effective diagnostic tool in making judgments about the heart's electrical activity and remains a non-invasive procedure. According to Nordgen (1970), the EKG can detect changes in the origin of the impulse, the heart rate and/or regularity, and changes in the QRS complex reflecting aberrant conduction, prolongation and general changes in configuration.

Monitoring equipment detects a single lead or view of the heart similar to the standard Lead II of the full EKG. This lead is effective in detecting the majority of arrhythmias, however there are other alternatives (Pinneo 1972). The standard Lead II along with the other limb leads do have several disadvantages; the two points of measurement are at a distance from the heart, and the electrodes are all in the frontal plane. When the electrodes are closer to the heart and moved around the thorax seeing the heart as three-dimensional, more information can be obtained. Theoretically, the  $V_1$  lead should give the most reliable

precordial pattern; however, that has not been shown with certainty (Marriott 1968).

The MCL<sub>1</sub> lead placement is a modification of the V<sub>1</sub> pattern of the full EKG. The MCL<sub>1</sub> placement gives the advantages of a right precordial lead plus leaving the left precordium free for examination and/or defibrillation if needed. "It is widely recognized that the single conventional lead that offers the most information about disturbances of rhythm and conduction is V<sub>1</sub>" (Schmidt 1969, p. 1). The diagnostic advantages of the MCL<sub>1</sub> placement are: well formed P waves, a clearer distinction between right and left ventricular ectopics, right and left bundle branch blocks, and left ventricular ectopics versus aberrant conduction (Marriott and Fogg 1970).

Electrodes closer to the electrical source, the heart, should register more of an effect on the EKG (Berson et al. 1970). Routinely, the transverse level of the ventricle is marked at the fifth intercostal space. "For transverse levels above the fourth or below the fifth intercostal space, progressive losses of voltage occurred with little further alterations in direction" (Gau and Smith 1971, p. 542). Of the placement patterns to be tested, only Lead 11 has one electrode below the level of the fifth intercostal space.

Occasionally, the CM<sub>5</sub> lead placement exhibits abnormalities in the EKG overlooked in other lead placement systems. This lead provides mainly a better view of the T wave as a possible indication of left ventricular enlargement (Kemp 1973).

In monitoring a patient, an unusual EKG pattern may be obtained from causes other than the electrical events of the cardiac cycle. A constant danger in continuous monitoring lies in resuscitative measures initiated due to EKG artifact rather than an actual change in the patient's condition. Artifacts, either mechanically or patient produced are unavoidable to a certain degree, yet every effort should be made to minimize them. To permit the recording of maximal electrical impulses, the electrodes should be placed over an area of the least muscle mass possible, usually over the sternum or ribs. In using the chest wall, the interference from muscle contraction is reduced along with the interference from any tremors of the hands, convulsive activity, or simply random movements. Every muscle gives off action potentials in performing work that can potentially interfere with the EKG. In addition, the electrodes are attached to a soft, flexible tissue which is constantly metabolizing, sweating, and sloughing off (Hanish et al. 1971).

A computerized Med-Line search was not successful in locating any additional studies which involved human subjects and compared lead placement patterns.

## CHAPTER 3

### METHODOLOGY

This chapter includes the research process utilized in this study. Included in this process was the research design, the population and sample tested, the method of data collection, the measurement tool used and the analysis of the data.

#### Research Design

The research design was comparative in nature to determine whether one of three electrode placement patterns tested would provide a more readable electrocardiographic write-out. Three separate electrode placement patterns were tested on each person in the study. A continuous EKG monitoring device was used to record the EKG pattern produced by each placement pattern.

The directors of nursing in the hospitals involved were contacted and permission was obtained for the study. If the hospital so required, the proposal was sent through their respective Human Rights' Committees.

The procedure is non-invasive and does not actively infringe upon the patients' rights. However, each patient was given a complete explanation of the procedure, the rationale for the procedure, the anticipated outcomes and the applicability. The study itself was brief as far as the patients were concerned, as it required an estimated 15 minutes per patient.

Each person tested was asked to give verbal consent to participate in the study. Each patient was assured that their future care would in no way be affected if they chose not to participate in the study.

### The Sample

The sample consisted of the patients who were receiving care, including cardiac monitoring, in the Coronary Care and/or Intensive Care Units at two hospitals. One of the hospitals had an eight-bed unit and the other a seven-bed unit. All of the patients in these units within the limitations outlined and who agreed to participate were included in the study. Thirty-three patients who agreed to participate were included in the sample and one patient refused. In addition, 17 healthy volunteers were included in the sample because time limitations on the researcher did not permit a larger patient sample to be tested.

### Data Collection

Each person tested was asked to allow the researcher to apply disposable chest electrodes in each lead placement pattern and to lie as still as possible while a six-inch strip was run following each of the three placement patterns. The electrodes were placed in the Lead II, CM<sub>5</sub> and MCL<sub>1</sub> patterns on each person tested. The Medi-Trace CF-20 Pregelled Chloride-Free disposable electrodes were used throughout the study.

Prior to running each strip, the EKG machines used were standardized according to Marriott's (1968, p. 10) definition: "When

one millivolt is thrown into the circuit, the baseline should deflect exactly ten millimeters." Consistent standardization ruled out the variable factor of gain settings on the EKG monitors which might have affected the QRS amplitudes.

The EKG strips run on each person were then compared. The amplitude of the QRS complex was measured on each strip with an Abbott EKG ruler which provided interval data. The P waves were measured using the EKG paper itself.

#### The Tool

An Abbott EKG ruler was chosen to measure the amplitude of the QRS complexes (Keuskamp 1959). The EKG ruler was more accurate than either inspection or the use of a conventional ruler divided into millimeters. When comparing values possibly close to one another, the highest discriminatory power available is desirable. If the QRS amplitude varied within a given strip, the tallest QRS complex obtained was measured.

#### Analysis of the Data

A comparison was made of three electrode placement patterns to determine optimal results. Initially, the mean heights of the QRS complexes in each electrode placement pattern was computed. The standard error of the mean was then computed for each lead. The standard error of the mean is "the standard deviation of the sampling distribution of means based on samples of a specified size" (Minium 1970, p. 227). The term standard error is used in place of standard deviation for the

standard error is derived from theory but the value behaves like the standard deviation. When each lead was compared with each of the other leads, the differences of the mean heights of the QRS complexes were computed. When comparing two leads, significance was established at the 0.05 level if the mean difference in QRS complex height was more than two times the standard error.

A multiple regression analysis, which is used to describe "how a dependent variable is related to two or more independent variables," (Wonnacott and Wonnacott 1970, p. 54) was run for each variable. The multiple regression analysis indicated the amount of influence exerted by each variable on the height of the QRS complexes especially.

The P waves were measured using the EKG paper itself. The average P wave height in each lead placement pattern was then computed and the averages compared.

## CHAPTER 4

### PRESENTATION AND ANALYSIS OF THE DATA

The data collected were compiled and analyzed by computer. The following chapter contains the characteristics of the sample, a summary of the findings, and the data analysis.

#### Characteristics of the Sample

The 50 persons tested during the study were selected as described in Chapter 3. All of the patients in the Coronary Care Units of two local hospitals who were otherwise eligible and gave their verbal consents were tested using each of the three placement patterns. Thirty-three of the persons tested were hospitalized. The age range in this group was 33 to 93, not all of whom were hospitalized for specific cardiac pathology. There were 27 males in this group and 6 females ranging in height from 5' to 6'3" and from 130 to 250 pounds in weight. None of the patients were currently receiving all of the medications considered, that is, Digitalis, Pronestyl and Quinidine. Only one of the patients was currently receiving Pronestyl, nine patients were receiving Digoxin, and five patients were receiving Quinidine.

Any combination of the three drugs was rare. Three patients were receiving Digoxin and Quinidine, and one patient was receiving Digoxin and Pronestyl. Two of the patients were on Quinidine alone, and five patients were receiving only Digoxin.

The remaining 17 persons in the sample were volunteers comprised of hospital personnel and students. The age range in this healthy volunteer group was 21 to 44, including 15 females and 2 males. In this group the heights ranged from 5' to 5'11" and the weights from 98 to 190 pounds. None of the volunteer group was currently taking any of the drugs outlined nor had any known cardiac pathology.

The 50 persons tested presented a marked diversity in all of the areas considered in the study. In scanning the 50 subjects, the age range was 21 to 93, the heights from 5' to 6'3" and the weights from 98 to 250 pounds. There was a total of 29 males and 21 females (see Table 1).

#### The Findings

The heights of the QRS complexes as measured by the Abbott ruler ranged from 6 to 34 in Lead 11, from 6 to 30 in Lead  $CM_5$ , and from 2 to 26 in Lead  $MCL_1$ . The P waves which were measured according to an arbitrary scale using the EKG paper ranged from 2 to 4 mm in height in Lead 11, from 0 to 3 in Lead  $CM_5$ , and from 0 to 3 in Lead  $MCL_1$ . The findings can be seen in Table 1.

No single electrode placement pattern was found that consistently gave the tallest QRS complexes. Lead 11 showed a mean QRS height of 18.16,  $CM_5$  showed a mean height of 14.8, and Lead  $MCL_1$  showed a mean QRS height of 11.72.

Because P waves are important in distinguishing variations in impulse formation from those of conduction within the cardiac cycle, the P waves were also measured from each of the EKG strips using an arbitrary scale. Zero represented a P wave not clinically present, or less than

Table 1. QRS Amplitudes, P Wave Heights, and Variables of the Study.

Patient	Age	Sex	Height	Weight	Digoxin	Pronestyl	Quinidine	Height of QRS Complex			Height of P Wave		
								CM <sub>5</sub>	MCL <sub>1</sub>	II	CM <sub>5</sub>	MCL <sub>1</sub>	II
1	71	M	5'6"	169	no	no	no	10	16	16	2	2	3
2	36	M	5'11"	165	no	no	no	18	2	14	2	2	3
3	64	M	5'8"	168	yes	no	yes	6	10	24	2	2	2
4	93	M	5'	140	no	no	no	10	16	18	*	*	*
5	70	M	5'9"	135	yes	no	yes	14	26	18	*	*	*
6	49	F	5'3"	165	no	no	yes	16	8	14	2	2	4
7	23	F	5'1"	131	no	no	no	16	6	20	2	1	2
8	63	F	5'1"	138	no	no	no	14	10	12	2	2	2
9	44	M	6'	173	no	no	no	16	20	20	3	2	3
10	49	M	5'9"	160	no	no	no	2	12	20	1	2	2
11	59	M	6'	190	no	no	no	10	6	8	2	2	3
12	85	M	5'9"	179	yes	yes	no	10	14	18	1	1	2
13	74	F	5'7"	130	yes	no	no	10	22	18	2	1	2
14	67	M	5'10"	147	yes	no	yes	8	10	10	*	*	*
15	79	F	5'2"	125	yes	no	no	20	8	12	*	*	*
16	58	F	5'4"	130	yes	no	no	6	8	6	2	1	2
17	33	M	6'3"	179	no	no	no	6	10	22	1	2	3
18	44	F	5'4"	165	no	no	no	18	24	14	3	3	3
19	44	M	5'5"	145	no	no	no	20	12	12	2	1	3
20	60	M	5'8"	185	no	no	no	12	16	26	*	2	*
21	81	M	5'8"	158	no	no	no	20	14	18	*	2	2
22	63	M	5'8"	162	no	no	no	26	6	20	2	1	3
23	37	M	5'11"	205	no	no	no	10	10	18	2	2	2
24	48	M	5'10"	179	no	no	no	10	16	16	2	1	3
25	25	F	5'4"	130	no	no	no	22	18	24	2	1	3
26	26	M	5'7"	205	no	no	no	14	16	14	2	2	2
27	68	M	5'6"	157	no	no	yes	24	18	20	2	2	2
28	66	F	5'4"	144	no	no	no	22	14	18	2	2	2
29	40	M	5'10"	174	no	no	no	8	8	14	1	1	2
30	50	M	5'5"	141	no	no	no	22	10	8	0	1	2
31	49	M	6'	190	no	no	no	24	12	28	2	1	3
32	22	F	5'3"	105	no	no	no	12	6	24	2	2	2
33	31	M	5'8"	145	no	no	no	30	10	16	3	1	3
34	26	F	5'5"	130	no	no	no	18	6	24	2	1	2
35	26	F	5'5"	98	no	no	no	14	4	24	2	1	4
36	58	M	5'8"	166	yes	no	no	26	20	10	3	3	3
37	28	F	5'3"	147	no	no	no	10	2	18	3	1	3
38	23	F	5'3"	125	no	no	no	10	4	20	1	1	2
39	21	F	5'6"	136	no	no	no	6	4	12	1	1	3
40	31	F	5'	155	no	no	no	6	8	18	0	1	2

Table 1.--Continued.

Patient	Age	Sex	Height	Weight	Digoxin	Pronestyl	Quinidine	Height of QRS Complex			Height of P Wave		
								CM <sub>5</sub>	MCL <sub>1</sub>	II	CM <sub>5</sub>	MCL <sub>1</sub>	II
41	52	M	6'	185	no	no	no	20	16	24	2	1	3
42	73	M	5'6"	140	yes	no	no	26	24	26	2	1	3
43	54	M	5'4"	166	no	no	no	26	20	10	2	0	2
44	68	M	6'	250	no	no	no	14	14	34	*	1	3
45	37	F	5'3"	137	no	no	no	16	6	22	2	1	3
46	30	M	5'11"	190	no	no	no	8	8	20	2	1	3
47	22	F	5'4"	113	no	no	no	10	4	18	2	1	2
48	23	F	5'8"	134	no	no	no	14	6	22	2	1	2
49	28	F	5'4"	120	no	no	no	8	14	26	*	0	2
50	23	F	5'2"	117	no	no	no	22	12	20	3	1	4

\* P wave indistinguishable.

1 mm deflection from the baseline. A score of 1 represented a 1 mm deflection from the baseline, a score of 2 represented a 2 mm deflection and so on. The measurement was done by inspection, only the researcher measuring the P waves. Should a P wave have measured  $2\frac{1}{2}$  mm for example, the  $\frac{1}{2}$  was consistently dropped giving a score of the lower number. If the P wave was diphasic, both the positive and negative deflections were added to complete the score (see Table 1).

Four of the patients were in atrial fibrillation and were not included in this portion of the study. Four additional persons were not

included because of electrical interference which rendered the P waves indistinguishable. If the height of the P wave was found to vary in a given strip, the tallest P wave present was measured. The average P wave height in Lead II was 2.57 mm, in Lead CM<sub>5</sub> 1.90 mm, and in Lead MCL<sub>1</sub> 1.39 mm.

#### Data Analysis

The data collected from the 50 subjects were processed through a computer for statistical analysis. The mean of the age variable was 47.8 years with a standard deviation of 19.9. The mean of the heights was 66.56 inches with a standard deviation of 3.65. The mean of the weights was 154.46 pounds, with a standard deviation of 28.87.

A multiple regression analysis and a correlation coefficient was done in relation to age, sex, height, weight, and whether the patient was receiving Digoxin, Quinidine, and Pronestyl with no significant findings. A discriminate analysis was run and the discriminate scores plotted. None of the variables correlated significantly with the QRS amplitude.

Each lead was compared with each of the other leads and the difference in QRS amplitude between the two leads was computed for each person in the study. The mean of this QRS amplitude difference was then computed. Given the variables Lead CM<sub>5</sub> and MCL<sub>1</sub>, the mean of the difference in QRS amplitude is 3.08 and the standard error is 1.082. Because the mean of the difference in QRS amplitude between the two leads is more than two times the standard error, Lead CM<sub>5</sub> gives a larger QRS amplitude than Lead MCL<sub>1</sub> with the difference significant at the 0.05

level. Given the variables Lead 11 and  $MCL_1$ , the mean of the difference in QRS amplitude is 3.36 and the standard error is 1.245. Again, the mean of the difference in QRS amplitude is more than two times the standard error with Lead 11 giving a larger QRS amplitude than Lead  $MCL_1$  with the difference significant at the 0.05 level. Given the variables Lead 11 and  $CM_5$ , the mean of the difference in QRS amplitude is 6.44 and the standard error 2.27. The difference in QRS amplitude here is more than two times the standard error with Lead 11 giving a larger QRS amplitude than Lead  $CM_5$  with the difference significant at the 0.05 level. In summary, Lead 11 gave the tallest QRS complex, Lead  $CM_5$  ranked second and Lead  $MCL_1$  ranked third, with the differences between the QRS amplitudes in the three leads significant at the 0.05 level.

A mean was then computed for the P wave heights in each of the placement patterns. The average P wave height in Lead 11 is 2.57 mm, in Lead  $CM_5$  1.90 mm, and in Lead  $MCL_1$  1.39 mm.

## CHAPTER 5

### DISCUSSION AND CONCLUSIONS

The results computed in the statistical analysis showed that the amplitude of the QRS complex was significantly largest in Lead 11, Lead CM<sub>5</sub> ranked second, and Lead MCL<sub>1</sub> ranked third in the sample tested. As an estimation, when the P waves were measured by inspection using the EKG paper itself, the results were exactly parallel. Lead 11 gave the tallest P waves, CM<sub>5</sub> ranked second and MCL<sub>1</sub> ranked third when measured as outlined. The analysis of QRS amplitude was corrected for any variable influence of height, weight, sex, age, and/or drugs.

The monitoring equipment used during the study was the Hewlett-Packard 1309 A monitor. The electrodes used remained constant except for rare occasions when the patient's own electrodes could not be removed. In those instances, the tracing was taken using the electrodes already in place, which were consistently arranged in the MCL<sub>1</sub> placement pattern.

The sites of electrode placement were not shaved prior to electrode application and may have conceivably altered the amplitude of the QRS complexes obtained from some of the males in the study.

The researcher is not proposing that Lead 11 is unequivocally the best lead to use in continuous cardiac monitoring. "It is possible to generalize only to a population from which the sample may be

considered a random sample" (Minium 1970, p. 252). In this study, there was a hypothetical population in that the sample was chosen for convenience. In the sample tested, however, Lead 11 gave the tallest average QRS complexes and P waves. The researcher rated the three most commonly used placement patterns in the event that an alternate lead placement pattern should be required.

In light of the findings, the researcher rejected the original hypothesis and accepted the null hypothesis. The MCL<sub>1</sub> placement pattern did not provide a significantly greater QRS amplitude than Lead 11 or CM<sub>5</sub>.

A readable EKG is not the only component of effective cardiac monitoring, however. A well-trained, observant staff is indispensable-- a staff that can effectively use the equipment, and act on the information obtained.

Kintzel (1971, p. 71) says:

It was not electronic equipment, but rather knowledge that led to the widespread use of constant monitoring of the EKG--the knowledge that arrhythmias were a common cause of death, that certain apparently inconsequential arrhythmias indicated a predilection to more ominous and life-threatening arrhythmias and that means became available to successfully interrupt this progression of events towards death.

Again, the researcher is not proposing that the height of the P waves and the QRS complexes are the only determinates in choosing the optimum lead placement pattern, but they are certainly important parameters. Personal preferences are a factor in choosing a lead depending on whether a positive or negatively deflected QRS is deemed easiest to interpret. Physical considerations such as dressings

may preclude the use of any one of the three leads. Local custom is another possible factor.

In this study, Lead 11 gave the most readable P waves and QRS complexes and is one of the standard leads of the 12 lead EKG. Lead 11 consistently gave a QRS complex of sufficient amplitude to be easily read. Leads  $CM_5$  and  $MCL_1$  occasionally showed small QRS complexes that would be virtually impossible to interpret from a monitor scope. Lead  $CM_5$  which ranked second, leaves both lower rib margins free and does not contain a shoulder electrode placement site which keeps interference from deltoid activity at a minimum. Lead  $MCL_1$  which ranked third in P wave and QRS amplitude also leaves both lower rib margins free.

This research was an effort to find the most readable P waves and QRS complexes to form the basis for effective detection and treatment of arrhythmias. In those situations where the nurse has a choice of lead placement, she may wish to utilize Lead 11 initially.

## CHAPTER 6

### SUMMARY AND RECOMMENDATIONS

The researcher conducted an experimental study in an effort to arrive at the electrode lead placement pattern which provided the most readable QRS complexes primarily. P waves were also measured as an addition to the study because of the recognized importance of the P wave in EKG interpretation. The study was planned to designate one of the three most common lead placement patterns as providing the most readable P waves and QRS complexes to result in economy of time on the nurses' part, more expert care for the patient, and more prompt and accurate diagnosis.

Leads 11,  $CM_5$  and  $MCL_1$  were applied to each of 50 persons, and the EKG strips obtained measured with an Abbott EKG ruler to determine the height of the QRS complexes, and the EKG paper itself was used to measure the P waves. Seven other variables were also considered. They were age, sex, height, weight, and whether the person was then receiving Digoxin, Pronestyl, and/or Quinidine.

The data analysis showed the mean heights of the QRS were consistently greater than twice the standard error for Lead 11 when compared with the other two leads and for lead  $CM_5$  when compared with Lead  $MCL_1$ . Consequently, the differences in the height of the QRS

between the three leads was significant at the 0.05 level. Although no lead was found to perform consistently on every person tested, Lead 11 gave the tallest average P waves and QRS complexes, Lead CM<sub>5</sub> ranked second and Lead MCL<sub>1</sub> ranked third both in height of the P wave and QRS complex. The analysis of the QRS amplitudes was corrected for any possible influence of the other variables considered.

#### Recommendations

On the basis of the findings in this study, it is recommended to:

1. Nursing Education--that student nurses and nurses in orientation be taught the different possible lead placements with the advantages and disadvantages of each.
2. Nursing Service--that in those situations where nursing does have a choice of lead placement, Lead 11 might be considered for initial lead placement.
3. Nursing Research--that a study similar to this one should be conducted using a larger sample. A more precise way of measuring both the P waves and QRS complexes might be obtained.

## SELECTED BIBLIOGRAPHY

- Andreoli, Kathleen, Virginia K. Hunn, Douglas P. Zipes and Andrew G. Wallace. Comprehensive Cardiac Care. St. Louis: C. V. Mosby Co., 1968.
- Arthur, R. M., David B. Geselowitz, Stanley A. Briller and Rudolph F. Trost. Human heart determined from surface EKG's. Journal of Electrocardiology, 4:29-33, 1971.
- Berson, A. S., Raul Gamboa, I. Alzona Naval and Hubert V. Pipberger. Positions in two corrected orthogonal lead systems. Journal of Electrocardiology, 3:29-42, 1970.
- Blake, Thomas M. Introduction to Electrocardiology. New York: Appleton-Century-Crofts, 1972.
- Day, Hughes W. Acute coronary care--A five-year report. American Journal of Cardiology, 21:252-257, 1968.
- Delano, Alice. Monitoring the acutely ill cardiac patient. Cardiovascular Nursing, 7:61-64, 1971.
- Duke, Martin. Unusual artifact in electrocardiology. Journal of the American Medical Association, 211:829, 1970.
- Duke, Martin. Artifacts in the electrocardiogram. Medical Trial Technique Quarterly, 17:377-387, 1971.
- Gau, Gerald T. and Ralph E. Smith. The effect of electrode position on a modified Frank electrovectorcardiographic lead system. Mayo Clinic Proceedings, 46:536-543, 1971.
- Golden, D. P., Donald G. Mauldin and Roger A. Wolthuis. "Real-Time Contourography, an Improved Electrocardiographic Display." IEEE Transactions on Biomedical Engineering, 17:296-302, 1970.
- Geselowitz, D. B. An application of electrocardiographic lead theory to impedance plethysmography. IEEE Transactions on Biomedical Engineering, 18:38-41, 1971.
- Hanish, H. M., R. A. Neustein, C. C. Van Cott and R. T. Sanders. Technical aspects of monitoring the heart rate of active persons. American Journal of Clinical Nutrition, 24:1155-1163, 1971.

- James, Thomas N. Changing concepts in electrocardiography. Modern Concepts in Cardiovascular Disease, 39:129-132, 1970.
- Kemp, George L. EKG abnormalities discovered with treadmill stress testing. Heart and Lung, 2:227-231, 1973.
- Keuskamp, D. H. A simple device for measuring time intervals in the EKG and for determining the electrical axis of the QRS complex. American Heart Journal, 57:389, 1959.
- Kintzel, Kay C. (ed.). Advanced Concepts in Clinical Nursing. Philadelphia: J. B. Lippincott Co., 1971.
- Lewis, Edith. Nursing in Cardiovascular Diseases. New York: American Journal of Nursing Company, 1971.
- Lown, B. and A. Selzer. The CCU--Pro and con. American Journal of Cardiology, 32:597-602, 1968.
- Marriott, H. J. Practical Electrocardiography. Baltimore: Williams and Wilkins Co., 1968.
- Marriott, H. J. and E. Fogg. Constant monitoring for cardiac dysrhythmias and blocks. Modern Concepts of Cardiovascular Disease, 39:6-104, 1970.
- McKenzie, F. L. Oscilloscope tracing of the cardiac cycle. Nursing Times, 65:18-20, 1969.
- Meltzer, L. E. Coronary care, electrocardiography and the nurse. American Journal of Nursing, 65:63-67, 1965.
- Meltzer, L. E., Rose Pinneo and J. Roderich Kitchell. Intensive Coronary Care--a Manual for Nurses. Philadelphia: Charles Press Publishers, 1969.
- Minium, Edward W. Statistical Reasoning in Psychology and Education. New York: Wiley and Sons, Inc., 1970.
- Nordgen, L. A new principal for automatic detection of QRS complexes with aberrant intraventricular conduction in a continuous EKG registration. Acta Soc. Med. Ups., 75:1-5, 1970.
- Pinneo, Rose. Cardiac monitoring. Nursing Clinics of North America, 7:457-467, 1972.
- Rytand, D. The midclavicular line: Where is it? Annals of Internal Medicine, 69:329-330, 1968.

- Schmidt, J. E. Medical Discoveries. Springfield, Illinois: Charles C. Thomas, 1959.
- Schmidt, J. E. Sophisticated Monitoring. Oldsman, Florida: Tampa Tracings, 1969.
- Takagi, M. The electrodes triangle. American Heart Journal, 80:427-428, 1970.
- Walton, J. H. (ed.). The Electrocardiogram in Myocardial Infarction. New Jersey: CIBA Pharmaceutical Co., 1968.
- Winsor, Travis. The EKG in myocardial infarction. Clinical Symposia, 20(4):3-6, 1968.
- Wonnacott, Ronald J. and Thomas H. Wonnacott. Econometrics. New York: Wiley and Sons, Inc., 1970.

