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# A Study of Variability in Locating the External Reference Point for Central Venous Pressure Determination

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# A STUDY OF VARIABILITY IN LOCATING THE EXTERNAL REFERENCE POINT FOR CENTRAL VENOUS PRESSURE DETERMINATION

by

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A Thesis in Partial Fulfillment

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Each person whose signature appears below certifies that he has read this thesis and that in his opinion it is adequate, in scope and quality, as a thesis for the degree Master of Science.

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# A STUDY OF VARIABILITY IN LOCATING THE EXTERNAL REFERENCE POINT FOR CENTRAL VENOUS PRESSURE DETERMINATION

This was an exploratory study to determine variability among intensive care nurses in locating, with two methods, the external reference point for central venous pressure (CVP) determinations. Thirty-one volunteer nurses and thirty-two volunteer subjects participated. The variability was great with both methods and was influenced by the method used; the subgroup; and the sex, age, weight, and height of the subjects.

Direct measurement of venous pressure has been used occasionally by physicians since the early 1900's (Hooker and Eyster, 1908), but only in recent years has central venous pressure (CVP) determination become a routine procedure. In fact, it has become so routine that today the physician generally depends on the nurse to make accurate observations of CVP after he places the central catheter.

Central venous pressure reflects the ability of the cardiac pump to circulate the actual blood volume in relation to the capacity of the circulatory system (Prout, 1970; Hurst, et al., 1971; Sessler, 1965; Borow, 1965; Wilson, et al., 1962; Hughes and Magovern, 1959). Three factors work together to determine the CVP: cardiac pump action, circulating blood volume, and vascular tone (Wilson, 1963, p. 471).

In making CVP determinations, the nurse must locate a point on the patient as an external reference for zero level. This should

coincide with the level of the right atrium of the heart or bear a constant relation to it since the minimum pressure in the circulatory system can be expected to occur in the right atrium (Rushmer, 1970, p. 194). Since the trend of CVP readings is more important than isolated, individual readings (Longerbeam, et al., 1965; Betson and Ude, 1969; Prout, 1970; Robson, 1968), all nurses should use the same point as zero level to establish a baseline for readings. An external mark (both tape and gentian violet: Barnwell and Edgecomb, 1964) on the patient provides a uniform reference point for the zero level for all medical personnel determining the CVP. When such an external mark is used, accurate comparison can be made between CVP readings for an individual patient. Since, however, the mark is sometimes removed by nurses because of previous "inaccurate marking" or just fades away, the mark has to be relocated, and the relocation process is often an inexact one which does not locate the mark exactly where it was before.

Unless patients are marked accurately according to identical specific criteria, correlations of CVP values between patients are difficult or impossible (Pederson, 1951-1952; Robson, 1968). Because of the lack of consistent criteria, one nurse may locate the reference point considerably higher or lower than another nurse. Thus, reported CVP values may be higher or lower than the accepted normal range.

Published studies on venous pressure show that a great lack of uniformity exists regarding the choice of a reference point and the specific criteria used in locating it. In fact, because of the error of measurement (Topping, 1965, pp. 9-13), even one nurse using specific criteria to locate a reference point on the same patient on several

different occasions may not always locate the identical point and thus not observe the same CVP value. With an increase in the number of nurses locating a reference point comes an increase in the possible variability.

The purpose of this study was to determine the variability which occurs when intensive care nurses locate CVP reference points. Two sets of criteria for locating a reference point were compared: 1) the guidelines used by individual nurses in locating the midaxillary or mid anterior-posterior chest diameter reference point and 2) the six-point guidelines developed by the author for locating an anterior axillary reference point.

## REVIEW OF THE LITERATURE

There are almost infinite possible external reference points to choose from for CVP determinations. Some investigators have explored a recommended location and its relationship to the right atrium (Lyons, et al., 1938; Pederson and Husby, 1951-52; Debrunner and Buhler, 1969; Taylor, et al., 1930; Wilson, 1962; Sessler, 1965; Ryan Yowland, 1966; Prout, 1970; Rushmer, 1970; Jereos, 1971; Wright, 1973). Others have examined factors which may cause discrepancies in CVP values (Lyons, et al., 1938; Rushmer, 1970; Selkurt, 1971; Debrunner and Buhler, 1969; Longston, 1971; Thomas, 1972; Long, et al., 1973). However, no studies have been found which examine the human variability involved in locating the reference point for CVP monitoring.

### Studies Related to the Location of the Reference Point

In the years since measurement of CVP began many persons have searched for the best location for the external reference point. There is general agreement that the reference point should be at the level of the right atrium of the heart or should bear a constant relation to it (Debrunner and Buhler, 1969). Since the actual position of the right atrium may differ from person to person in relation to any external reference point, this may introduce error in CVP readings. In this review of literature, studies dealing with the location of the external reference point are considered first.

In 1938 Lyons and his associates listed, with the normal ranges, many of the reference points used for venous pressure

determinations until that time. Selecting three of these points, which were more frequently used, these researchers made CVP readings which they then compared with values determined by using a point they had located ten centimeters anterior to the back of the thorax. Ninety normal subjects with varying thoracic diameters were used in their study. They found that use of the three selected points, which were influenced by the anterior-posterior chest diameter, resulted in wide ranges of venous pressure and showed an inverse relationship between the thoracic diameter and venous pressure. As the thoracic diameter increased, the venous pressures tended to decrease. They concluded that when the reference point was located ten centimeters anterior to the back of the thorax, the range of venous pressure was narrower and the pressure values of subjects with large chests were equally distributed on each side of the mean pressure value (Lyons, et al., 1938).

Pederson and Husby (1951-52) also studied the choice of the external reference point for zero level in CVP determinations. From their survey of previous studies, they found that the reference points fell into three main groups according to the method followed to locate them: 1) measuring a fixed distance from the anterior surface of the chest, 2) measuring a fixed distance from the posterior surface of the chest, and 3) measuring a distance relative to the anterior-posterior chest diameter. In their investigations Pederson and Husby, in order to locate the position of the catheter in the chest, examined X-ray films taken during cardiac catherization of eighteen patients. After studying the films, they determined a zero level reference point by measuring from the anterior surface of the sternum at the fourth

intercostal space a distance of 0.43% of the chest thickness. When this reference point was used for CVP monitoring on forty normal adults, Pederson and Husby found no significant relationship between the venous pressures and thoracic diameters. Then, on the same forty adults, they used the same four reference points Lyons had studied. Pederson and Husby found that use of the Lyons reference point produced the widest range of CVP values and the greatest differences between patients with small and with large chests. Further examination of the CVP values for each of the reference points used revealed that the reported normal range of values was noticeably different among the three groups of investigators involved--the original authors, Lyons and associates, and Pederson and Husby. Perhaps a variability among the investigators in actually locating the reference points could explain the observed differences reported as normal range values for CVP even though they reportedly used the same reference point for their studies.

Other authors studied the significance of the reference point in CVP determinations. In 1969 Debrunner and Buhler compared seven methods of locating the external reference point in terms of 1) normal range in centimeters of water for each reference point and 2) actual distance in centimeters--derived from the radiologically measured distance--of the reference point from the tip of the catheter placed in the superior vena cava directly cephalad to the right atrium. These actual distances varied from 3.38 cm. below the catheter to 6.62 cm. above the catheter. The discrepancies found in the CVP values were attributed to the different reference points used. Debrunner and Buhler concluded that CVP values can not be compared with one another

when different methods for locating the reference point are used.

However, even for one method, inadequately defined criteria may also result in apparent discrepancies in the CVP values. The literature reveals a lack of uniformity regarding the recommended reference point. Those who use the midaxillary point, for example, do not clearly define how that point is determined (Taylor, et al., 1930; Wilson, 1962; Sessler, 1965; Ryan and Howland, 1966; Prout, 1970). Does the nurse estimate by sight the middle of the axilla? Or does she find, at the intercostal level, the actual midpoint between the lateral border of the pectoralis major, which forms the anterior axillary fold, and the border of the latissimus dorsi, which forms the posterior fold of the axilla (Gray, 1910, pp. 1427-1428)?

Another aspect in the location of the reference point is the position of the patient. When man is standing with the longitudinal axis of the body parallel to the force of gravity, gravity exerts a strong influence on the long columns of blood (Rushmer, 1970, p. 196). Theoretically, when man assumes the recumbent, supine position--usually considered standard for making CVP determinations (Andreoli, et al., 1968; Betson and Ude, 1968; Colditz and Josey, 1970; Maier and Goldman, 1968; Pederson and Husby, 1951-52; Wilson, F., et al., 1968)--the longitudinal axis is perpendicular to the force of gravity; and the influence of gravity is negligible. Thus, one would expect the patient to have the same CVP whether he was lying on his back or on his side. Considering this principle of hydrostatic pressure, Jereos (1971) investigated the effects of lateral positioning on CVP. She used a midaxillary reference point for the patient in the supine

position and a point at the fourth intercostal space within the right sternal border for the patient in the side-lying position. She found that CVP readings taken at fifteen minute intervals were not the same when the patients were lying on their back as when they were lying on their sides. This study stimulated Wright (1973) to seek to discover whether the reference points used by Jereos were actually representing the mid right atrium.

Wright, studying twenty-two postmortem subjects, found that a probe inserted at the commonly used midaxillary reference point was consistently posterior to the mid right atrium level by about three centimeters. When she inserted the probe at the sternal reference point, she found no consistent relationship between the point and the mid atrium. She concluded that an anterior axillary line reference point would more accurately correspond with the height of the mid right atrium. Then the question arose: Can nurses, knowing that the right atrium is at a level of the anterior axillary line, consistently locate the same external reference point?

These studies by Jereos and Wright were a stimulus for this investigation of variability among nurses in locating the prescribed CVP reference points.

## Studies Related to Factors Other Than Reference Point Causing CVP Value Discrepancies

Considered in this section are factors other than location of the external reference point which could cause discrepancies in CVP values. These include the apparatus used in measurements, the physiologic state of the subject, the magnification factor of X-rays, and

the location of the catheter tip.

Lyons, et al., (1938) studied and reviewed the first factor. In their examination of the manometer tube system which they used in CVP determinations, they found an error of 1.2 cm. in all reported readings when the diameter of the manometer tube was 0.2 cm. or less. When larger tubing was used, the readings showed no significant errors. Neither needle sizes between gauge fourteen and gauge twenty-five nor minor variations in the tubing length caused significant error in readings.

Variations in the physiological state of the individual may cause CVP variations. Changes in respiration affect the CVP slightly due to fluctuations in the intrathoracic pressure (Rushmer, 1970, p. 204; Selkurt, 1971, p. 368). In some circumstances, such as with shock, venous pressure is abnormally low because of decreased blood volume, reduction in venous tone and/or decrease in muscle activity and in skeletal muscle tone (Selkurt, 1971, p. 370).

The magnification factor of X-rays was considered in the study made by Debrunner and Buhler. They derived the actual distance from the reference point to the catheter by dividing the radiologically measured distance by 1.2, the magnification factor of X-rays. For instance, a thoracic diameter which measured 25.9 cm. radiologically was actually only 21.6 cm. (Debrunner and Buhler, 1969). Thus any actual distance on a subject was increased by a factor of 1.2 when measured on X-ray, under the conditions of Debrunner and Buhler's study.

The last factor considered as a possible source of error in

reported CVP readings was the location of the catheter tip. Langston (1971), Thomas (1972) and Long, et al., (1973) pointed out that incorrect positioning of the catheter tip can yield misleading CVP values and can cause several complications. In one case, Long, et al. reported a CVP reading of 20 cm. $H_2O$ with the catheter tip in the proximal right pulmonary artery and a reading of -2 cm. $H_2O$ when the catheter was withdrawn to the superior vena cava (1973).

Knowledge of these factors and of the potential errors which they could introduce in CVP readings allows the practitioner to make necessary corrections or adjustments. While 1) apparatus, 2) physiological state of the subject, 3) magnification of X-rays, or 4) location of the catheter tip each has its importance, in all the studies which this writer has seen there have been no references to the human variability in locating the reference point.

## Studies Related to Variability

Two main causes of variability among nurses locating the CVP reference point are thought to be errors of measurement and differences in criteria used.

Variability due to error of measurement. The error of measurement or observation is the difference between an observed value and the "accurate" value (Topping, 1965, p. 9; Weld, 1917, p. 11). In a series of individual observations the mean value represents the best estimate of the actual quantity being measured. All measurements are inaccurate in some degree. The greater the number of observations the nearer the mean value approaches the "accurate" value (Topping, 1965, p. 13).

In an error of measurement study, the proportion of the total number of observations whose error lies between any assigned limit can be determined (Brunt, 1917, p. 8). For example, 95% of observations fall between plus and minus 1.96 standard deviations from the mean. The observations can be described in terms of any unit such as inches, feet, centimeters.

Errors made in measurements are often classified either as systematic or random. Topping (1965, p. 14) divided the systematic errors into two categories: 1) error of the instrument and 2) error of the observer. Error of the instrument may be due to errors in construction or in actual working of the instrument. Error of the observer may be due to personal idiosyncrasies or habits of observation. An observer may always measure a distance longer or shorter than it really is. An experienced and careful observer usually commits errors in the same direction. Such factors as a change of vision, inattention, and fatigue can influence the pattern of the experienced observer. The inexperienced observer sometimes overestimates and other times underestimates in making a measurement and commits errors of varying size (Brunt, 1917, p. 3). In many cases the causes of systematic errors can be eliminated, avoided, or adjusted for.

Random errors, which result from unknown causes, are also known as accidental errors. They may be due to carelessness in the handling of an instrument, such as reading one number and writing down another; reading the wrong number on the scale; or sighting the scale from a position not level with a vertical point. Random errors may also result from external causes such as movement of the measuring

tool without the observer's awareness or rapid change in the wind or temperature of the environment (Weld, 1917, p. 16). The effect of random errors can be reduced through making a series of observations (Brunt, 1917, p. 5; Topping, 1965, p. 12).

Variability due to criteria. In a study of variability more is involved than just measurement of a line or a distance. There are a number of variables which could be factors in affecting the differences among nurses locating an external CVP reference point. One of the main factors could be a difference in criteria used or in understanding of the criteria. When location of anatomical landmarks is a part of the criteria for identification of a reference point, a difference in skills may be apparent among the nurses.

## Purpose

The purpose, then, of this study was to determine the variability which occurs when intensive care nurses locate CVP reference points. In the five-hundred-bed medical center where this study was conducted there is an increasing tendency to use the anterior axillary line and fourth intercostal space rather than the midaxillary line or midpoint anterior-posterior chest diameter as the reference point for CVP monitoring. This tendency came as a result of recommendations in a recent film developed by Roche Inc. (1972) and as a result of the findings in the study by Wright (1973). When a change in reference point is to be made, it is important to avoid misinterpretations of CVP readings. Both physicians and nurses need to consider all factors which could be sources of potential discrepancies

in the CVP readings. As pointed out in the need for this study, it is important that all nurses are able to find the chosen reference point easily, accurately, and consistently.

## METHODOLOGY

This was an exploratory study to determine variability among intensive care nurses in locating the external reference point for CVP determinations. The study involved location of the reference point as well as measurement of the distance from either the shoulder or the posterior surface of the back to the reference point. Using two methods, experienced nurses located extrathoracic reference points on volunteer subjects. Variance was analyzed to determine what sources influenced the variability among the nurses.

### Study Design

Thirty-one intensive care nurses who routinely were involved in CVP monitoring and marking reference points on patients were the nurse participants in this study. Thirty-two volunteer subjects with varying body builds and without clearly abnormal chest structure or vertebral columns were used for the location of the extrathoracic reference points. A convenience sampling of sixteen males and sixteen females was included.

Since it was inconvenient and appeared impossible to assemble all subjects and nurses at the same time, eight subgroups were formed, each containing four subjects and four nurses, except for Subgroup One, which had only three nurses.

Each nurse located, measured, and recorded in writing a CVP external reference point on each subject in her group twice, using first Method I, then Method II, both defined below.

In the entire study each nurse located 8 points; each subgroup, except for Subgroup One, 32 points; all nurses, 248 points.

Definitions

Nurse Participants in this study were registered nurses who worked in the intensive care surgical units in a medical center where they regularly located extrathoracic reference points and made CVP readings.

Unit I referred to a general surgery intensive care nursing unit in the medical center.

Unit II referred to a cardiothoracic surgery intensive care nursing unit in the same medical center.

Subjects were sixteen men and sixteen women, nonpatients, who volunteered to permit nurses to locate on them an external reference point for CVP readings.

Method I designated the working criteria each nurse used for the location of the external reference points for CVP monitoring. The points located by this method were either mid-axillary or midpoint anterior-posterior chest diameter, the ones regularly used at the medical center where this study was conducted.

Method II consisted of following the criteria specified by the researcher for locating an anterior axillary line reference point for CVP monitoring (see p. 20). This point was chosen since it was shown to approximate more closely the level of the right atrium (Wright, 1973).

A Subgroup included four subjects and four nurses. The four nurses were all from one unit.

The Measuring Device was a special tool designed to insure accuracy in describing the location of the exterior reference points found on the subjects by the nurses. It consisted of a three-inch-wide, two-foot-long board attached at right angles to a one-inch-wide board equipped with a centimeter scale. With the two-foot board slipped under the back of the subject, the nurse could measure the vertical distance from his back to the reference point she had located. A similar centimeter scale was prepared to measure horizontal distance from the shoulder to the reference point. See Figure I, p. 17, for a picture of the measuring device.

## Variables

The variables were factors in the study design which might have contributed to variability among the nurses in locating the reference points. They included: nursing unit, method, subgroup, and sex of subjects. Covariables included the quantity units of age, height, and weight of the subjects.

## Description of the Participants

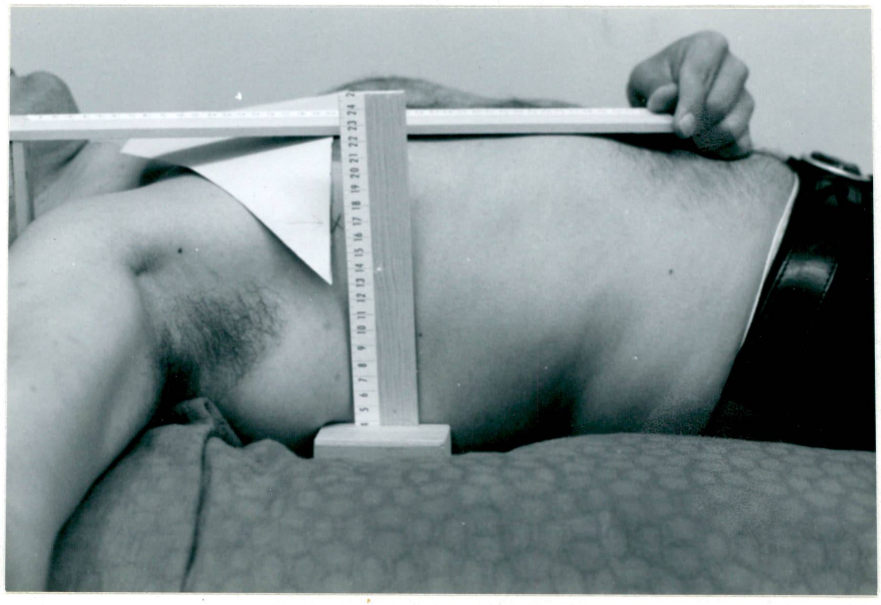
Subjects. For this study subjects of varied ages, heights, weights, and body builds were included in the sample since nurses locate the CVP reference point on many varied sizes of patients.

The sixteen female subjects ranged in age from 18 to 85 years, in height from 59 to 67 inches, and in weight from 83 to 172 pounds.

The sixteen male subjects ranged in age from 22 to 67 years, in height from 61 to 78 inches, and in weight from 111 to 228 pounds.

The means of the covariables of the subjects used by the

FIGURE I. MEASURING DEVICES USED IN DESCRIBING THE LOCATED REFERENCE POINT IN TERMS OF CENTIMETERS ABOVE THE POSTERIOR SURFACE OF THE SUBJECT (VERTICAL) AND CENTIMETERS FROM THE TOP OF THE SHOULDER (HORIZONTAL).



nurses to locate the CVP reference points can be seen on Table I, page 19.

Nurses. Thirty-one intensive care nurses who routinely were involved in CVP monitoring and marking reference points were the volunteer registered nurse participants. Fifteen nurses were from Unit I, general surgical intensive care unit; and sixteen were from Unit II, cardiothoracic surgical intensive care unit. Some nurses from each of the three shifts participated: days, seventeen; afternoons, nine; and nights, five.

Nurses from these two surgical intensive care units were included in the study since they had had the most opportunity to locate external reference points. Also, nurses were included from all three shifts since all the nurses locate reference points at times and take CVP readings.

## Limitations

The nurse participants were volunteers from the surgical intensive care nursing units of a specific medical center. Therefore these findings could not be applied directly to other settings.

## Pilot Study

A pilot study was done to test the measuring tools and the guidelines for the two methods. Two intensive care nurses and two subjects participated. Results of the pilot study showed that, after slight modifications, the measuring tools were acceptable. After minor changes had been made in the guidelines for Method II, a third intensive care nurse was readily able to follow them.

TABLE I. MEAN VALUES FOR THE COVARIABLES OF THE SUBJECTS USED BY NURSES TO LOCATE THE POINTS FOR CVP MONITORING

| Unit | Number of Subjects | Females | | | Males | | |
|---|---|---|---|---|---|---|---|
| | | Age in yrs. | Height in in. | Weight in lbs. | Age in yrs. | Height in in. | Weight in lbs. |
| I | 16 | 43 | 62 | 132 | 30 | 69 | 168 |
| II | 16 | 40 | 62 | 130 | 37 | 68 | 164 |

Additional information can be found on Appendixes E and F where the mean values are divided according to subgroup and sex.

Data Collection

Participating nurses were divided into subgroups and scheduled for gathering the data. Each nurse was shown on a subject how to use the measuring tools. Guidelines for each method were given to the nurses as follows:

GUIDELINES

Guidelines for Method I: Location of midaxillary or midpoint of anterior-posterior chest diameter reference point

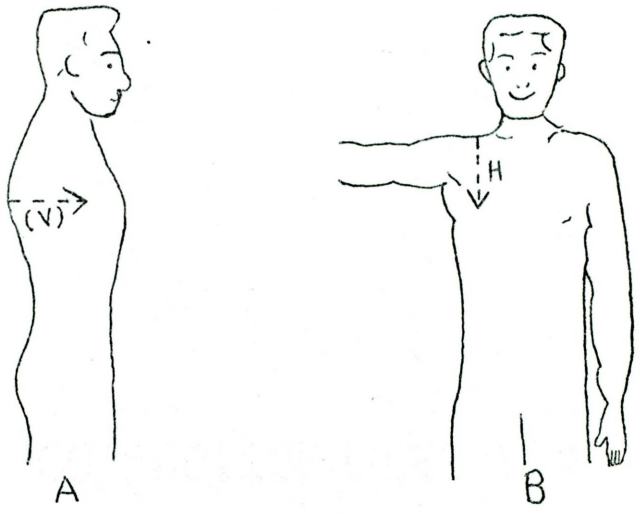
1. Have the subject's right arm abducted horizontally at a right angle to the body.
2. Use the criteria which you currently use on the unit to locate the reference point for CVP monitoring.
3. Mark the point with a star sticker provided.
4. Describe the point in terms of centimeters above the posterior surface (Vertical) and centimeters down from the shoulder (Horizontal). See diagrams below.
5. Describe the criteria you used to locate the point.
6. Remove the sticker.

Guidelines for Method II: Location of anterior axillary reference point

1. Have the subject's right arm abducted horizontally at a right angle to the body (abduct--to move away from the median plane of the body; see Diagram B).
2. Find the 4th intercostal space to the right of the sternum and extend a line perpendicularly to the right with use of the right angle provided.*
3. With the subject in the same position, locate the level of the anterior axilla.
4. At the point where a straight line parallel to the sternum from the level of the anterior axilla and the line from the 4th intercostal space cross (which is actually at the 5th intercostal space at the level of the anterior axilla) place a star sticker.*

5. Describe this point using the rules provided, in terms of centimeters above the posterior survace (V for Vertical in Diagram A) and down from the top of the shoulder (H for Horizontal in Diagram B) on the paper provided. The centimeter rule down from the shoulder should be parallel to the sternum.

6. Remove the sticker and measuring rules.




*Inclusion of the following would have made the guidelines clearer.

1. Method II, #2. Find the 4th intercostal space to the right of the sternum and extend a line perpendicular to the sternum and to the right with use of the right angle provided.

2. Method II, #3. With the subject in the same position, locate the anterior axillary line, the lateral border of the pectoralis major muscle, at the axilla since this is where it is best defined.

3. Method II, #4. From this level of the anterior axilla (#3) extend a straight line parallel to the sternum. Where this line crosses the line from the 4th intercostal space found in step 2 (which is actually at the 5th intercostal space at the level of the anterior axilla) place a star sticker.

4. Identical instructions for use of the measuring tools in Method I and Method II.

When the volunteer subjects, who had signed a consent from (see Appendix G), arrived at the designated room, they were given verbal explanations and instructions. Screening and draping provided privacy

for the subjects to disrobe to the waist and don hospital gowns. As the subjects lay supine in hospital beds, each of the four nurses in each subgroup located on each subject in her group a reference point, using Method I, marked it with a star sticker, measured its location horizontally and vertically with the measuring device (see definitions on p. 15), and recorded in writing the location of the point according to the measurements. She then described in writing the criteria she had used in locating the point and removed the sticker. Then, using Method II, she repeated the procedure except for the description of criteria.

Processing of the Data

The processing of the data included the following divisions:

1. Estimates of variability
    a. Method I
    b. Method II
2. Variation within the units, between the methods
    a. Vertical measurement
    b. Horizontal measurement
3. Variation within the methods, between the units
    a. Vertical measurement
    b. Horizontal measurement

# RESULTS

The variability involved in the use of two methods for determination of the external reference point for CVP monitoring are reported in this section. Analysis of data was done for all the measurements made with each method to determine the variability occuring among the nurses. This analysis was based on a total variance for the fifteen nurses from Unit I, for the sixteen nurses from Unit II, and then for the total thirty-one nurses from both units. Data were further analyzed to compare all measurements, both vertical and horizontal, made in Method I with all those made in Method II and to compare nurses from Unit I with those from Unit II for each method. These analyses were based on a general linear model with computation of F-ratio statistics for each of the sources of variability. For the linear model computations, the standard deviations from the means of the horizontal and vertical measurements located by four nurses on each subject were used as an index of variability.

## Estimates of Variability

Figure II shows, in lengths of 95% confidence intervals, the variability among the nurses when locating the external reference point for CVP determinations. Standard deviations used in determining these 95% confidence intervals were based on the pooled variances of all the nurses from each unit. For each subject a variance among the nurses was found. These variances were totaled. Then the standard deviation was found by taking the square root of the mean of the

FIGURE II. VARIABILITY (SHOWN AS LENGTHS OF 95% CONFIDENCE INTERVALS) AMONG NURSES IN LOCATING THE EXTERNAL REFERENCE POINT FOR CVP DETERMINATION

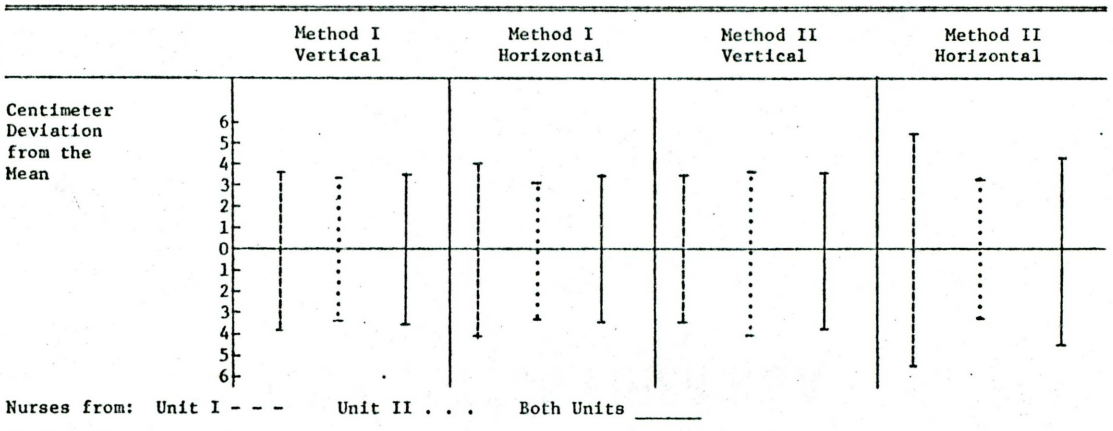



TABLE II. VARIABILITY EXPRESSED AS LENGTHS OF 95% CONFIDENCE INTERVALS

| Unit | Method I Vertical | | | Method I Horizontal | | | Method II Vertical | | | Method II Horizontal | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | Both | I | II | Both | I | II | Both | I | II | Both |
| 95% Con. Int. in cm. | 7.12 | 6.43 | 6.78 | 7.88 | 6.23 | 7.06 | 6.98 | 7.21 | 7.09 | 10.82 | 6.24 | 8.52 |
| Actual distance of mean cm. from posterior surface | 12.0 | 11.8 | 11.9 | 20.7 | 20.1 | 20.4 | 14.3 | 15.6 | 15.0 | 19.8 | 20.0 | 19.9 |

variances. The variability involved in the vertical and the horizontal measurements of the reference point for each method were analyzed separately.

Presented first are the over-all general comparisons of the variability at the 95% confidence interval (± 1.96 standard deviations) for all nurses using Method I for location of the reference point. Then the same comparisons are shown for Method II.

Results showed that for both methods there was large variability in the measurements reported. The lengths of the 95% confidence intervals are diagramed on Figure II and listed in Table II (see p. 24).

Method I. The smallest variability observed was a confidence interval of 6.23 cm. when Unit II nurses located the horizontal component of the reference point using Method I--the individual nurse's criteria. In other words, 95% of nurses locating a CVP reference point could be expected to locate the point within a range of 6.23 cm. The lengths of other 95% confidence intervals can be seen diagramed on Figure II.

Method II. The greatest variability observed was a 95% confidence interval of 10.82 cm. when Unit I nurses located the horizontal component of the reference point using Method II--the specified criteria. The lengths of other 95% confidence intervals for Method II can be seen on Figure II.

Variation Within the Units, Between the Methods

A comparison was made between the use of Method I and Method

II by Unit I nurses and by Unit II nurses. Analysis of the sources of variability in this section included the method used; the subgroup; and the sex, age, height, and weight of the subjects. The analysis was done to find which variables, if any, had significant effect on the variability of the nurses from each unit. See Table III, page 27, for a listing of the F-ratios for each of the sources of variability.

The main purpose in doing an analysis between the methods was to find out whether the method used was significant in affecting the amount of variation among the nurses. In other words, does the F-ratio show a difference between Method I and Method II when nurses used them to locate and describe the vertical and horizontal measurements of a CVP reference point?

Analysis of the data showed that the subgroup as a source of variability was significant in affecting the determination of both the vertical and the horizontal measurements. This could be expected because of individual nurse differences. This analysis did not show whether any one subgroup had more effect than another. The estimates of variability divided by subgroups for Unit I nurses can be seen on page 48, Appendix C, and for Unit II nurses on page 49, Appendix D.

Vertical measurement. The F-ratio showed no significant difference between the amounts of variation in Method I and Method II.

For the Unit I nurses none of the sources of variability was observed to affect significantly the determination of the vertical measurement.

For the Unit II nurses the subgroup and sex, age, and height

TABLE III. ANALYSIS OF VARIANCE, WITHIN UNITS, BETWEEN METHODS*

Variability among nurses in locating the external reference point for CVP determination.

| Source of Variance | D.F. | Unit I, Vertical F-Ratio | Sig. | Unit I, Horizontal F-Ratio | Sig. | Unit II, Vertical F-Ratio | Sig. | Unit II, Horizontal F-Ratio | Sig. |
|---|---|---|---|---|---|---|---|---|---|
| Method | 1 | 0.03 | N. S. | 11.42 | P<.01 | 0.29 | N. S. | 0.37 | N. S. |
| Subgroup | 3 | 1.89 | N. S. | 6.41 | P<.01 | 3.29 | P<.05 | 1.70 | N. S. |
| Sex | 1 | 3.16 | N. S. | 2.18 | N. S. | 4.69 | P<.05 | 2.12 | N. S. |
| Cov. 1, Age | 1 | 1.61 | N. S. | 12.19 | P<.01 | 6.38 | P<.05 | 1.95 | N. S. |
| Cov. 2, Height | 1 | 4.49 | N. S. | 7.20 | P<.05 | 5.37 | P<.05 | 2.18 | N. S. |
| Cov. 3, Weight | 1 | 0.68 | N. S. | 10.47 | P<.01 | 4.21 | N. S. | 2.53 | N. S. |

*Standard deviations figured on each subject were used as the index of variability.

D.F. = Degrees of Freedom
Sig. = Significance Level
N.S. = Not Significant
Cov. = Covariant

$F_{95}(1,15)$ = or >4.54

$F_{99}(1,15)$ = or >8.68

$F_{95}(3,15)$ = or >3.29

$F_{99}(3,15)$ = or >5.42

of the subjects were observed to affect the determination of the vertical measurement at 5% levels of significance. The vertical measurements on males varied less than those on females. And as the age and the height of the subjects increased, the variability among the nurses decreased.

Horizontal measurement. For the Unit I nurses an F-ratio of 11.42 showed a significant difference at the 1% level between the use of the two methods in locating the horizontal measurement for the CVP reference point (see Table III, p. 27). The variability among them was 7.88 cm. using Method I and 10.82 cm. using Method II, showing less variation among the Unit I nurses when they used Method I. This is shown graphically on Figure II (p. 24).

For the nurses of Unit I, F-ratios for 1% levels of significance were observed for the following sources of variability: method, subgroup, age, and weight. The height variable had a F-ratio for 5% level of significance. Age and height were inversely related to the variability among the nurses so that as the age and height increased the variability decreased. As weight increased the variation also increased.

For the nurses of Unit II, none of the sources of variability was observed to significantly influence the determination of the horizontal measurement.

Variation Within the Methods, Between the Units

A comparison was made of the variability existing between the nurses on Unit I and the nurses on Unit II for each of the two methods

used in locating the external reference point for CVP. Analysis of the sources of variability included the unit, and the sex, age, height, and weight of the subjects. Analysis was done to find which variables had a significant effect on the nurses' variability when the amount of variability between the nurses of the two units was compared.

The main purpose in doing an analysis between the units was to find out whether the unit on which the nurses worked was a significant factor influencing the variability among the nurses. In other words, does the F-ratio show a significant difference between the nurses of Unit I and II in using either Method I or Method II for determining vertical or horizontal measurements?

Vertical measurement. No significant difference was observed in the variability between the nurses of the two units in using the two methods to locate and measure the vertical component of the reference point.

Horizontal measurement. When Method II was used for determining the horizontal measurement, the values reported by Unit I nurses had a greater variability than did those reported by Unit II nurses. This is shown graphically on Figure II, p. 24. An F-ratio of 20.65 for a 1% significance level was observed for the unit variable. See Table IV, p. 30, for a complete listing of the F-ratios. No other variables were observed to influence significantly the determination of the horizontal measurement.

TABLE IV. ANALYSIS OF VARIANCE, WITHIN METHODS, BETWEEN UNITS*

Variability among nurses in locating the external reference point for CVP determination.

| Source of Variance | D.F. | Method I, Vertical F-Ratio | Sig. | Method I, Horizontal F-Ratio | Sig. | Method II, Vertical F-Ratio | Sig. | Method II Horizontal F-Ratio | Sig. |
|---|---|---|---|---|---|---|---|---|---|
| Unit | 1 | 0.01 | N. S. | 1.80 | N. S. | 0.03 | N. S. | 20.65 | P<.01 |
| Sex | 1 | 3.89 | N. S. | 1.23 | N. S. | 0.02 | N. S. | 0.10 | N. S. |
| Cov. 1, Age | 1 | 0.03 | N. S. | 0.00 | N. S. | 1.00 | N. S. | 0.42 | N. S. |
| Cov. 2, Height | 1 | 2.47 | N. S. | 0.57 | N. S. | 0.06 | N. S. | 0.22 | N. S. |
| Cov. 3, Weight | 1 | 1.37 | N. S. | 0.02 | N. S. | 0.02 | N. S. | 1.24 | N. S. |

*Standard deviations figured on each subject were used as the index of variability.

D.F. = Degrees of Freedom
Sig. = Significance Level
N.S. = Not Significant
Cov. = Covariant

$F_{95}(1,20)$ = or >4.35

$F_{99}(1,20)$ = or >8.10

Criteria Used by Nurses for Method I

The criteria used for Method I, as described by thirty of the participating nurses, included many varied responses (Appendixes A and B).

Vertical measurement. For the vertical component of the reference point, twelve nurses mentioned "midaxillary"; ten, descriptions of one-half anterior-posterior chest diameter; and eight, versions of estimating the point visually.

Horizontal measurement. For the horizontal component fourteen responses included "nipple line"; seven, the fourth intercostal space; one, the fifth intercostal space; and the remaining eight, no specific reference to the horizontal measurement.

It was evident that no exact criteria had been followed by all the nurses. It was noted at the times of data collection that several nurses did not really have clear criteria; rather, they estimated the point. This could show they had not given much thought to the actual anatomy of the person in relation to CVP; or perhaps they had not thought of the exact location as being important. Another possible reason for lack of clear criteria could be the fact that the participating nurses were experienced in locating reference points for CVP determination, and through the process of experience had developed an intuitive sense of where the point should be.

## DISCUSSION

The findings of this exploratory study showed that a large variability existed among intensive care nurses locating a CVP reference point. The variability occurred both when nurses used varied criteria, but a method familiar to them, and also when they used specified but new criteria.

As noted in the rationale for this study, many studies have been done on CVP; but no studies were found dealing with the human variability involved in locating the reference point. While it has been accepted that CVP values determined by different methods can not be compared with each other (Debrunner and Buhler, 1969), this current study seemed to indicate that neither can they be reliably compared even when the same method is used for locating the reference point.

The object of this study was not to relate the location of the reference point to the level of the right atrium (Lyons, et al., 1938; Pederson and Husby, 1951-52); but rather to find out if a number of different nurses could consistently locate the same reference point on a given subject. It seems appropriate that nurses select a method that will lend itself to finding a point most easily and consistently and then use it. This would promote the most effective evaluation of patients' conditions and most valid comparisons among patients.

In this study the subjects were all in a flat supine position throughout the time period when data collection occurred. The

variability therefore could not occur because of changes in the position of the subjects. In a clinical situation it sometimes is difficult to place the patient completely flat, and CVP readings are taken when the patient is elevated slightly, i.e., thirty degrees, or rotated. No attempt was made to apply the findings in this study to patients in other than the supine position. However, the importance of clear criteria for CVP determination and consistency in the application of such criteria are strongly inferred in literature reviewed and in results reported in this study. Consistency in application of criteria for CVP determinations will provide measurements which can be evaluated for the trend of values in a given patient and for comparisons of readings with expected normal values.

Method. The greatest variability occurred among nurses when they used Method II in locating and describing the horizontal measurement of the reference point. In Method II the nurses were asked to locate the fourth intercostal space, while in Method I the nurses tended to use the nipple line as the landmark for the horizontal measurement. Perhaps this accounts for the differences between the methods. With the subject lying in the supine position, the nipple line landmark tends to be fairly stable and easily identified. Palpating for a specific intercostal space is not always so easy as observing the location of the nipple. A lack of knowledge of how to locate the fourth intercostal space, or how to count the spaces, or of experience in palpating the intercostal space might explain the large variability of the reported values for the horizontal measurement

in Method II. In Morris' Human Anatomy, edited by Anson, guidelines are given for determining the number of an intercostal space.

> A space has the same number as the rib superior to it. . . The first space is immediately inferior to the clavicle, but it is palpated with greater difficulty than the second because the clavicular head of the pectoralis major muscle and the clavipectoral fascie tend to obscure its boundaries. The second is well defined as it lies lateral to and slightly below the sternal angle (p. 23).

Clinically, the location of the horizontal component of the reference point has little significance except in the case where borders of the pectoralis major and latissimus dorsi mucles are used to locate a midaxillary reference point. If these muscles are used, the vertical component of the point would be lower, for example, at the third intercostal space level than at the fifth intercostal space level. Since the vertical measurement is the level used as zero level in CVP readings, it is the most important component of the reference point.

Before collecting the data for this study, none of the nurses had used the specific criteria required for Method II. Had they had training and experience with this method, perhaps the variability of their measurements would have been greatly reduced. During the data collection periods it was noted that many nurses relied heavily on their past experience in locating a reference point and could not readily describe precise criteria they had used.

Unit. The difference in variability between the units might be related to the amount of experience of the nurses. Generally, there is a greater turnover of patients, and hence more CVP monitoring

on Unit II than on Unit I. Also, Unit II nurses had begun to use an anterior axillary line reference point on patients although their guidelines were not the same as those given by the researcher in this study.

Subgroup. Each subgroup consisted of four nurses locating a reference point for CVP determination with each of two methods on four subjects. For this study it would have been desirable to have all nurses locate the reference points on one group of subjects at the same data collection period; but this was impossible because of the nurses' work schedules. Because of the necessity to divide the nurses into subgroups, the subgroup was included in the analysis of variance between the two methods. It was expected that there would be some difference among the subgroups because of individual nurse differences which will always be present. Further study with a different grouping of nurses would be required to evaluate better the effect of the subgroup on variability.

Sex, age, height, and weight of the subject. When Unit II nurses located the vertical component of the reference point on females, greater variation occurred among them than when they located the point on males. Pedersen and Husby (1951-52) stated that on females there is a tendency to place the axilla lines more posteriorly because of the mammary tissue in the anterior fold of the axilla. While this study did not show the anterior axillary line in females to be posterior to that in males, possibly some of the experienced nurses subconsciously made allowance for the mammary tissue when

locating the point on females.

As age and height of the subject increased, the variability among the nurses decreased. The vertical component of the point may have been easier to locate in older and taller subjects because the border of the pectoralis major muscle is more clearly observable in them. In location of the horizontal component of the point, weight had a significant effect. As weight increased, the variability also increased. These relationships might be due to a greater ease in palpating the intercostal spaces on older, taller, and thinner people. This indicates a need for nurses to be extremely careful when locating the CVP reference point on young, short, and obese patients. There is an evident need for a method of locating a reference point which can be more easily and consistently located on people of all body builds.

Since this study involved error of measurement, variability among the nurses could be attributed in part to the use of the measuring tools themselves. Such variability, however, would not be expected to be as great as that found in this study.

## SUMMARY AND CONCLUSIONS

The purpose of this exploratory study was to determine variability among intensive care nurses in locating, with two methods, the external reference point for central venous pressure (CVP) determinations. The thirty-one participating nurses were those who routinely were involved in monitoring CVP and in marking CVP reference points. Thirty-two non-hospitalized subjects volunteered to permit the nurses to locate on them the CVP reference points.

Analysis of the data showed variability existing among the nurses when locating the CVP reference point by both methods used. The greatest variability occurred when nurses used specified, unfamiliar criteria for locating the horizontal component of the reference point. The sex, age, height and weight of the subjects were also factors which affected the nurses' variability in locating the reference point.

## RECOMMENDATIONS

Recommendations are suggested which might be useful to the nursing profession in improving the accuracy of CVP reference point location.

Recommendations for inservice education for nurses:

1. Inservice education should be given all intensive care nurses in the use of specific criteria for location of CVP reference points. Periodic evaluation of their continued application of the given criteria when marking CVP reference points on the patients could be done to determine the usefulness of such education.

2. Each nurse who is learning to locate CVP reference points perhaps should locate and describe the vertical and horizontal components of the reference point five times and take the average of the results as the actual point.

3. The administration should provide easy-to-operate measuring devices for nurses to use to aid in locating the reference point and describing the location on the nursing care plan.

Studies testing the validity of the following hypotheses might be a real contribution to nursing care and education:

1. There will be less variability among nurses locating the external CVP reference point after they have had five consecutive days of experience in the use of Method II with slightly revised criteria.

2. There will be less variability among nursing students learning to locate the CVP reference point on the fourth data collection period using revised Method II than on previous data collection

periods.

3. There will be less variability among nurses locating the external CVP reference point when they use a method not requiring location of anatomical landmarks than when they use revised criteria for Method II.

# BIBLIOGRAPHY

BIBLIOGRAPHY

Andreoli, Kathleen G., Virginia K. Hunn, Douglass P. Zipes and Andrew G. Wallace. Comprehensive Cardiac Care: A Handbook for Nurses and Other Paramedical Personnel. St. Louis, C. V. Mosby Company, 1968.

Anson, Barry J., editor. Morris' Human Anatomy 12th ed. New York, The Blakiston Division McGraw-Hill Book Co., 1966.

Barnwell, Benjamin B. and Erman Edgecomb. The role of the central venous determination in the management of the surgical patient. Journal of the National Medical Association 56:482-486, Nov. 1964.

Betson, Carol and Linda Ude. Central venous pressure. American Journal of Nursing 69:1466-1468, 1969.

Bloomfield, Richard A., Henry D. Lauson, Andre Cournand, Ernest S. Breed and Dickinson W. Richards, Jr. Recording of right heart pressures in normal subjects and in patients with chronic pulmonary disease and various types of cardio-circulatory disease. Journal of Clinical Investigation 25:639-663, 1946.

Borow, Maxwell, Lawrence Aquilizan, Adrianne Krausz and Anastassios Stefanides. The use of central venous pressure as an accurate guide for body fluid replacement. Surgery, Gynecology and Obstetrics 120:545-552, March, 1965.

Brisman, Ronald, Leon C. Parkes and Donald W. Benson. Pitfalls in the clinical use of central venous pressure. Archives of Surgery 95(6):902-907, Dec. 1967.

Brunt, David. The Combination of Observations. Cambridge, University Press, 1917.

Central Venous Pressure Measurement. American College of Physicians, Medical Skills Library. A Product of Roche. New Jersey, Division of Hoffmann-LaRoche Inc., 1972.

Colditz, Richard S. and William E. Josey. Central venous pressure in supine position during normal pregnancy. Obstetrics and Gynecology 36(5):769-772, Nov. 1970.

Dean, Virginia. Measuring venous blood pressure. American Journal of Nursing 63:70-72, Oct. 1963.

Debrunner, Felix and Fritz Buhler. Normal central venous pressure: significance of reference point and normal range. British Medical Journal 3:148-150, July 19, 1969.

Friedman, Edward, Ernest Gragle and Jacob Fine. Central venous pressure and direct serial measurements as guides in blood-volume replacement. Lancet 2:609-613, Sept. 17, 1966.

Gray, Henry. Anatomy, Descriptive and Applied 18th ed. Philadelphia, Lea and Febiger, 1910.

Hallin, Roger W. Continuous venous pressure monitoring as a guide to fluid administration in the hypotensive patient. American Journal of Surgery 106:164-170, August 1963.

Harris, I. Venous pressure in heart disease. Edinburgh Medical Journal 35:630-650, 1928.

Hooker, D. R. and J. A. Eyster. An instrument for the determination of venous pressure in man. John Hopkins Hospital Bulletin 19: 274-277, Sept. 1908.

Hurst, Victor W., Wade Scott Weems, John N. Wilson and James Anderson Wood. What CVP can and cannot tell you about patients in shock. Patient Care March 15, 1971, pp. 102-115.

Jereos, Romelda. Effect of Lateral Positioning on Central Venous Pressure. Unpublished Master's Thesis, Loma Linda University, Loma Linda, Calif., 1971.

Johnson, Martha S. Nurses' guide to central venous pressure monitoring. Military Medicine 135:100-106, Feb. 1970.

Landis, Eugene M. and John C. Hortenstine. Functional significance of venous blood pressure. Physiological Reviews 30:1-32, January 1950.

Langston, Charles S. The aberrant central venous catheter and its complications. Radiology 100:55-59, July 1971.

Long, Madeleine L., Linette Javid and Robert G. Hauser. Complications of central venous pressure monitoring: cardiac arrhythmias and conduction disturbances. Heart & Lung 2(3):416-421, May-June 1973.

Lyons, Richard H., J. Allen Kennedy and C. Sidney Burwell. The measurement of venous pressure by the direct method. The American Heart Journal 16(6):675-691, Dec. 1938.

Maier, Willis P. and Leonard I. Goldman. The nurses' role in central venous pressure monitoring. A O R N Journal 8(6):35-37, Dec. 1968.

Maier, Willis P., Leonard I. Goldman and George P. Rosemund. Central venous pressure monitoring. Penn. Medicine 72:58-61, Feb. 1969.

Pedersen, Asger and Jacob Jusby. Venous pressure measurement. Acta Medica Scandinavica 141:185-194, 1951-1952.

Piro, David F. Central venous pressure monitoring by percutaneous infraclavicular subclavian vein catheterization. South Dakota Journal of Medicine 22:94-97, Oct. 1969.

Prout, V. G. Central venous pressure monitoring: theoretical and practical considerations. Triangle--the Sandoz Journal of Medical Science 9(5):174-178, 1970.

Robson, Martin C. Technique for obtaining accurate reproducible central venous pressure monitoring. John Hopkins Medical Journal 22:232-235, Jan.-June, 1968.

Rushmer, Robert F. Cardiovascular Dynamics 3rd ed. Philadelphia, W. B. Saunders Company, 1970.

Ryan, Gail M. and William S. Howland. An evaluation of central venous pressure monitoring. Anesthesia and Analgesia 45(6):754-759, Nov.-Dec. 1966.

Selkurt, Ewald, editor. Physiology 3rd ed. Boston, Little, Brown and Company, 1971.

Sessler, A. D. and E. A. Moffitt. Measurement and interpretation of venous pressure during surgery. Surgical Clinics of North America 45:852-862, 1965.

Taylor, F. A., A. B. Thomas and H. G. Schleiter. A direct method for the estimation of venous blood pressure. Proceedings of the Society for Experimental Biology and Medicine 27:867-871, 1930.

Thomas, Thomas V. Location of catheter tip and its impact on central venous pressure. Chest 61(7):668-673, June 1972.

Topping, J. Errors of Observation and Their Treatment 3rd ed. London, Chapman and Hall, Limited, 1965.

Weil, Max Harry, Herbert Shubin and Leonard Rosoff. Fluid repletion in circulatory shock: central venous pressure and other practical guides. Journal of the American Medical Association 192(8):668-674, May 24, 1965.

Weld, LeRoy D. Theory of Errors and Least Squares. New York, The Macmillan Company, 1916.

Wilson, F., J. H. Nelson and A. Moltz. Methods and indications for central venous pressure monitoring. American Journal Obstetrics and Gynecology 101(1):137-151, May 1, 1968.

Wilson, John. The management of acute circulatory failure. Surgical Clinics of North America 43:469-495, April 1963.

Wilson, John N., John B. Grow, Charles V. Demong, Arthur E. Prevedel and J. Cuthbert Owens. Central venous pressure in optimal blood volume maintenance. Archives of Surgery 85:563-578, Oct. 1962.

Witte, Albert A. Central venous pressure and blood volume relationships. Journal of the American Osteopathic Association 68:382-390, Dec. 1968.

Wright, Jane. Extrathoracic reference point measured internally on post-mortem subjects. In progress Master's Thesis. Loma Linda University, Loma Linda, Calif., 1973.

# APPENDIXES

Appendix A. List of Criteria Used by Nurses for Method I*

Unit I General Intensive Care Unit

Nipple line, one-half way between patient's anterior and posterior sides or midaxillary

4th intercostal space and midchest

4th intercostal space to midaxillary

Picked from visualization of midaxillary point

Midaxillary, nipple line (3)

Midpoint down counting 4th intercostal and nipple line

I measure down to 5th intercostal space and mark a point midaxillary (usually midway just below nipple)

Midaxillary and midsternum with patient flat (2)

I look at patient's chest and look for midsternum from tip of sternum to bottom next to bed

Have patient lie flat on bed and about 3-4 in. below the nipple line down the midaxillary.

Find the sternum with right hand--place left hand behind back. Approximate the halfway point between chest and small of back. Have patient flat.

Midaxilla and a little above or right at nipple line, just by sight.

*Direct quotes used.

Appendix B. List of Criteria Used by Nurses for Method I*

Unit II Cardiothoracic Surgical Unit

Eye sight, made mark below nipple line

Midaxillary, nipple line and estimation (2)

Counted down to 4th intercostal space, estimated through midaxillary

Midaxillary and approximately level of apex of heart

Midaxillary, nipple line (2)

Visual sight of midaxillary, one-half way between bed and anterior axillary and 4th intercostal space

Eye judgment, 4th intercostal space (2)

Midway between anterior and posterior and corresponding with nipple line (3)

Visual only

Usually eyeball the location, using the nipple and axilla for points of reference

*Direct quotes used.

Appendix C. Variability Findings for Unit I Nurses Divided by Subgroups*

Division by subgroups of mean values for age, height, and weight of the subjects and the standard deviations of the vertical (V) and horizontal (H) measurements determined by the nurses of Unit I using both Method I and Method II.

| | Subjects | | | | Method I | | Method II | |
|---|---|---|---|---|---|---|---|---|
| Subgroups** | Actual No. | Age | Height | Weight | Standard Deviation | | Standard Deviation | |
| | | | | | V | H | V | H |
| 1 | 4 | 38 | 67 | 167 | 0.79 | 1.96 | 1.41 | 2.89 |
| 2 | 4 | 26 | 69 | 175 | 2.60 | 0.91 | 1.92 | 2.22 |
| 3 | 4 | 58 | 65 | 132 | 1.21 | 1.18 | 1.42 | 1.31 |
| 4 | 4 | 24 | 63 | 124 | 1.65 | 2.76 | 1.30 | 3.74 |
| 1-4 | 16 | 37 | 66 | 150 | 1.56 | 1.70 | 1.51 | 2.54 |

*Standard deviation for these figures was determined on an individual subject basis rather than from the population variance.

**Each subgroup consisted of four nurses locating a reference point for CVP determinations with each of the two methods on four subjects, two male and two female, with the exception of subgroup one which had only three participating nurses. (N = 120 V; 120 H)

Appendix D. Variability Findings for Unit II Nurses Divided by Subgroups*

Division of subgroups of mean values for age, height, and weight of the subjects and the standard deviations of the vertical (V) and horizontal (H) measurements determined by the nurses of Unit II using both Method I and Method II.

| | Subjects | | | | Method I | | Method II | |
|---|---|---|---|---|---|---|---|---|
| Subgroups** | Actual No. | Age | Height | Weight | Standard Deviation V | Standard Deviation H | Standard Deviation V | Standard Deviation H |
| 5 | 4 | 27 | 65 | 139 | 1.12 | 0.62 | 1.02 | 1.39 |
| 6 | 4 | 34 | 69 | 152 | 1.41 | 1.12 | 1.23 | 1.28 |
| 7 | 4 | 69 | 64 | 148 | 2.06 | 2.27 | 2.88 | 1.55 |
| 8 | 4 | 25 | 64 | 149 | 1.36 | 1.41 | 1.22 | 1.77 |
| 5-8 | 16 | 39 | 65 | 147 | 1.49 | 1.35 | 1.59 | 1.50 |

*Standard deviation for these figures was determined on an individual subject basis rather than from the population variance.

**Each subgroup consisted of four nurses locating a reference point for CVP determinations with each of the two methods on four subjects, two male and two female. (N = 128 V; 128 H)

Appendix E. Variability Findings for Unit I Nurses Divided by Subgroups and Sex*

Division by subgroups and sex of mean values for age, height, and weight of the subjects and the standard deviations of the vertical (V) and horizontal (H) measurements determined by the nurses of Unit I using both Method I and Method II.

| | Subjects | | | | Method I | | Method II | |
|---|---|---|---|---|---|---|---|---|
| Subgroups** | Actual No. | Age | Height | Weight | Standard Deviation V | Standard Deviation H | Standard Deviation V | Standard Deviation H |
| 1 | 2 Male | 34 | 70 | 178 | 0.58 | 2.92 | 0.95 | 3.30 |
| | 2 Female | 43 | 64 | 156 | 1.00 | 1.01 | 1.86 | 2.48 |
| 2 | 2 Male | 26 | 73 | 209 | 2.58 | 0.61 | 3.03 | 1.86 |
| | 2 Female | 27 | 65 | 141 | 2.61 | 1.21 | 0.81 | 2.58 |
| 3 | 2 Male | 37 | 70 | 154 | 1.19 | 1.19 | 2.07 | 1.37 |
| | 2 Female | 79 | 60 | 111 | 1.24 | 1.18 | 0.77 | 1.26 |
| 4 | 2 Male | 25 | 65 | 130 | 1.60 | 2.24 | 1.20 | 3.68 |
| | 2 Female | 23 | 60 | 118 | 1.71 | 3.29 | 1.40 | 3.51 |
| 1-4 | 8 Male | 30 | 69 | 168 | 1.48 | 1.74 | 1.81 | 2.55 |
| 1-4 | 8 Female | 43 | 62 | 132 | 1.64 | 1.67 | 1.21 | 2.53 |

*Standard deviation for these figures was determined on an individual subject basis rather than from the population variance.

**Each subgroup consisted of four nurses locating a reference point for CVP determinations with each of the two methods on four subjects, with the exception of subgroup one which had only three participating nurses. (N = 120 V; 120 H)

Appendix F. Variability Findings for Unit II Nurses Divided by Subgroups and Sex*

Division by subgroups and sex of mean values for age, height, and weight of the subjects and the standard deviations of the vertical (V) and horizontal (H) measurements determined by the nurses of Unit II using both Method I and Method II.

| | Subjects | | | | Method I | | Method II | |
|---|---|---|---|---|---|---|---|---|
| Subgroups** | Actual No. | Age | Height | Weight | Standard Deviation V | Standard Deviation H | Standard Deviation V | Standard Deviation H |
| 5 | 2 Male | 34 | 67 | 138 | 0.53 | 0.69 | 0.85 | 1.38 |
| | 2 Female | 20 | 62 | 141 | 1.71 | 0.54 | 1.19 | 1.41 |
| 6 | 2 Male | 25 | 73 | 176 | 1.33 | 0.57 | 0.98 | 0.95 |
| | 2 Female | 44 | 65 | 128 | 1.48 | 1.68 | 1.49 | 1.61 |
| 7 | 2 Male | 61 | 67 | 171 | 2.46 | 2.24 | 3.29 | 1.71 |
| | 2 Female | 76 | 61 | 124 | 1.67 | 2.30 | 2.47 | 1.41 |
| 8 | 2 Male | 28 | 66 | 168 | 1.28 | 1.22 | 0.74 | 1.57 |
| | 2 Female | 22 | 63 | 129 | 1.44 | 1.59 | 1.71 | 1.96 |
| 5-8 | 8 Male | 37 | 68 | 164 | 1.40 | 1.18 | 1.46 | 1.40 |
| 5-8 | 8 Female | 40 | 62 | 130 | 1.57 | 1.53 | 1.71 | 1.60 |

*Standard deviation for these figures was determined on an individual subject basis rather than from the population variance.

**Each subgroup consisted of four nurses locating a reference point for CVP determinations with each of the two methods on four subjects. (N = 128 V; 128 H)

SUBJECT CONSENT FORM

This study is being conducted to find out which external point, among three that are currently being recommended by various authorities, would best identify the level of the heart and could be located the most easily and consistently by different nurses.

Two of the above points will be located on each subject by four different nurses. The points will be found on the right side of the chest and marked with a red dot sticker which will be removed after the point is identified in centimeters. Your height and weight will be recorded.

You will be asked to disrobe to the waist and wear a hospital gown to cover the chest area. Screens and beds are available in Room 9002 in Loma Linda University Medical Center where the study will be conducted. Nurses from intensive care units, 7100 and 8100, who routinely locate these external reference points on patients will be the nurses participating in this study. Time involvement is anticipated to be about thirty minutes.

I consent to volunteer to participate in this study as a subject as described above. (Date) _____ (Name) _____

(Date) _____ (Witness) _____

LOMA LINDA UNIVERSITY

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# A STUDY OF VARIABILITY IN LOCATING THE EXTERNAL REFERENCE POINT FOR CENTRAL VENOUS PRESSURE DETERMINATION

by

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ABSTRACT

This exploratory study was conducted to determine the variability occurring among intensive care nurses in locating, with two methods, the external reference point for central venous pressure (CVP) determinations. In the literature on CVP and on CVP value discrepancies, no reports were found of studies related to variability among medical personnel in locating the point.

The nurse participants in this study were thirty-one intensive care nurses who routinely were involved in CVP monitoring and marking reference points on patients in two surgical intensive care units. Thirty-two volunteer, non-hospitalized subjects, ages 18-85, sixteen males and sixteen females, with varying body builds and without clearly abnormal chest structure or vertebral columns were used for the location of the reference points. Eight subgroups were formed for data collection with four nurses and four subjects per subgroup. However, subgroup one had only three nurses.

Each nurse located, measured, and recorded in writing an external reference point for each of the two methods used on the four subjects in her subgroup. Method I designated the working criteria each nurse used for the location of the external reference point for CVP monitoring. Method II consisted of following the criteria specified by the researcher for locating an anterior axillary line reference point. For both methods nurses described the reference point in terms of centimeters above the posterior surface of the flat, supine subject

(Vertical) and centimeters down from the top of the shoulder (Horizontal). They used special measuring devices developed for this purpose.

Data were analyzed for (1) estimates of variability in centimeter units, (2) variation within the nursing units between the methods, and (3) variation within the methods between the nursing units.

Both methods used showed variability existing in the located reference points. The greatest variability occurred when nurses used Method II for locating the horizontal component of the reference point.

In the analysis between the methods the age and height of the subject were found to be significant factors affecting the nurses' variability in locating both the vertical and horizontal components of the reference point. Sex was found to be a significant factor when nurses located the vertical component, while weight was a significant factor affecting the nurses' variability when they located the horizontal component.

In the analysis between the nurses of the two units the only variable having significance was the method used in determining the horizontal component.

The 95% confidence intervals for all nurses using Method I to locate the CVP reference point was 6.78 centimeters for the vertical component and 7.06 centimeters for the horizontal component. The 95% confidence intervals for all nurses using Method II was 7.09 cm. for the vertical component and 8.52 cm. for the horizontal component. Possible reasons for the amount of variability observed are discussed in the study.