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Assessment of agreement between invasive and non-invasive blood pressure measurements in critically ill patients

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CHAPTER 5

SUMMARY OF STUDY, MAIN FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

5.1 INTRODUCTION

The final chapter of the research report presents a summary of the study, main findings, and conclusions from the main findings. This will be followed by a discussion of the limitations of the study and recommendation for clinical practice, nursing education, and for further research in this area.

5.2 SUMMARY OF THE STUDY

Blood pressure monitoring is essential for the management of critically ill patients in critical care units. Effective blood pressure monitoring can give data that permit analysis of key circulatory functions and the anticipation of deterioration so that pro-active treatments and intervention can be initiated. However blood pressure monitoring is associated with controversies as there are two types of blood pressure measurement techniques that tend to have wide discrepancy. As a result of that discrepancy nurses are often challenged as to which blood pressure measurement technique they should base their clinical decision making on.

Current clinical practice indicates that nurses often use the two measurements interchangeably based on the higher reading irrespective of which technique they use. Incorrect decision making may result in inappropriate administration of fluids or inotropes

due to unreliable data and may lead to prolonged hospitalization due to mismanagement; it can also lead to irreversible patient complication such as pulmonary edema, cardiac failure or loss of life.

In order to optimize nursing care in our critical care units, evidenced based research should be applied, and practices that are based on preferences, myths, or on old traditions should be avoided or used with clear evidence based guidelines. Assessment of the limits of agreements between invasive blood pressure and non invasive blood pressure is important in order to curb or minimize confusions that surround the two blood pressure measurement techniques.

5.2.1 Purpose of the study

The purpose of the study was to describe and compare the two blood pressure techniques IBP and NIBP in order to assess the limits of agreement between the two blood pressures obtained on patients in the adult critical care units in a tertiary health care institution, to determine the difference in terms of accuracy and sensitivity, to determine the factors that affect accuracy of both techniques , as well as to describe the reasons given by practitioners for their choice of blood pressure monitoring techniques.

5.2.2 Objectives of the study

The objectives of the study were:

- To establish whether there is a difference in terms of accuracy and sensitivity in the assessment of blood pressure using two different techniques of blood pressure monitoring.
- To determine what the difference is in terms of accuracy and sensitivity
- To determine the factors that affect accuracy of both techniques in the critical care unit.
- To elicit the reasons given by clinical practitioners for their choice of blood pressure monitoring techniques in the critical care unit.

5.2.3 Methodology

A quantitative, non experimental, descriptive and comparative prospective two parts study design was used to meet the study objectives. The population consisted of the patients admitted in the adult critical care units (n=5) of a large tertiary teaching hospital. Non probability purposive sampling method was used to select eighty (n=80) patients with the age limit of 18 to 50 years old who participated in part one of the study. Convenience sampling method was utilized to select fifty (n=50) clinical practitioners working in the critical care units as participants in the second part of the study. Data collection was done over the period of eight months. In consultation with a statistician descriptive and inferential statistics were used to analyze the data.

5.3 MAIN FINDINGS

In this study, the measurements of IBP and NIBP, the difference in terms of accuracy and sensitivity in the assessment of blood pressure using two different techniques of blood pressure monitoring. Factors that were affecting the blood pressure were obtained from 80 patients (n=80) in five critical care units of a tertiary teaching hospital as well as the reasons given by clinical practitioners for their choice of blood pressure monitoring techniques from 50 clinical practitioners (n=50) in the five critical care units.

The difference, strength of the relationship (correlation) together with the limits of agreement between IBP and NIBP were measured in three sections of systolic BP, diastolic BP and mean BP for all 80 subjects, and according to their time of collection.

Starting on systolic blood pressure, it was found that there were significant differences between the two methods on average (p=0.007).The p value was 0.007<0.05 of the level of significance which meant that invasive and non invasive measurements methods were significantly different. The IBP was 2.15 mmHg higher on average compared to NIBP systolic method. It was concluded that IBP and NIBP measurement methods were not related.

The Bland Altman analysis was used to assess the level of the agreement between IBP systolic and NIBP systolic, the Bland Altman analysis indicated that the 95% limits between the two methods ranged from -30.36 and +34.66 **(**refer to **figure 4.3)**. This means that the IBP systolic tends to underestimate the NIBP reading by as much as 30.36 mmHg and overestimate the non invasive systolic BP by up to 30.37 mmHg. The two methods did

not consistently provide similar measurements because there was a level of disagreement that included clinically important discrepancies of up to 35 mmHg. This illustrates that the IBP systolic and NIBP systolic methods can not be used interchangeably in the critical care unit. These findings were consistent with other literatures (Araghi, et al, 2006; Liehr, et al, 1995). In most of the studies, cuff sizes, arm position, or arm movement, quick deflation of cuffs, peripheral vascular diseases, presence of arrhythmias during the measurement of the blood pressure are some of the contributing factors to high discrepancy, many studies also stated that systolic blood pressure is the most sensitive parameter compare to others. (Bovet, Hungerbuhler, Quilindo, Grettve, Waeber & Burnand, 1995; Netea, Lenders, Smits & Thien, 1999). The focus here is to see how one measurement method can be used in order to reduce cost and allay all confusion of two conflicting blood pressure measurements in decision making in critical care unit, these findings were consistent with other literatures (Araghi, Bander & Guzman, 2006; Liehr, Dedo, Torres, & Mattoo, 1995).

The mean average over different hours, the underestimation was 30.89 mmHg and overestimation was 34.05 mmHg. The time difference of arterial line insertion within 48 hours did not make any significant difference on discrepancy of IBP systolic and NIBP systolic.

The same was done on IBP diastolic and NIBP diastolic measurement, the difference, strength of the relationship (correlation) together with the limits of agreement between IBP diastolic and NIBP diastolic were measured for all 80 subjects and it was found that there was no significant differences between the two methods on average ($p=0.239 > 0.05$) level of significance meant that IBP diastolic and NIBP diastolic measurements methods were not significantly different. The IBP diastolic was 2.143 mmHg lower on average compared

to NIBP diastolic BP method but not significantly different. In **figure 4.5**, Correlation(r) = 0.513 ($p<0.001$) the probability is very small, therefore it was concluded that IBP and NIBP diastolic are related, however this correlation does not mean that these two methods agree.

All 80 subjects in **figure 4.6** were plotted to measure the limits of agreement between invasive diastolic blood pressure (IBP) and non-invasive diastolic blood pressure (NIBP). The limits of agreements were between -18.51 and 19.49. This meant that the IBP diastolic could underestimate the NIBP diastolic by 18.51 and overestimate it by 19.49 mmHg. This illustrates that the IBP diastolic and NIBP diastolic methods can not be used interchangeably in critical care unit because of high discrepancy of about 19.5 mmhg. These findings were consistent with other literatures (Araghi, et al, 2006; Liehr, et al, 1995). The mean average over different hours the underestimation was 19.92 mmHg and overestimation was 20.13 mmHg.The time difference of arterial line insertion did not make any significant difference on discrepancy of IBP diastolic and NIBP diastolic.

The same Bland Altman analysis and test to see if there was a significant difference between the two methods of IBP mean and NIBP mean was done and it was found that there was no significant difference between the two methods. On average, the p-value was $0.443>0.05$ of the level of significance meaning that IBP mean and NIBP mean measurement methods were not significantly different. The IBP mean was 1.013 higher compared to NIBP mean method but not significantly different. Correlation(r) = 0.087($p<0.001$) the probability was very small and it can be concluded that IBP and NIBP mean BP are related; however this correlation does not mean that these two methods agree. The correlation(r) measures the strength of the relationship between two variables not the

agreement between them. The limits of agreement was found to be -17.23 and 19.25 **(figure4.9)** this means that IBP mean tend to underestimate the NIBP mean reading by as much as 17.23 and overestimate NIBP mean by up to 19.25.

The two methods did not consistently provide similar measurements because there was a level of disagreement that included clinically important discrepancies of up to 19.3 mmHg. This illustrates that the IBP mean and NIBP mean methods can not be used interchangeably in critical care unit. These findings are in agreement with previous studies on comparison of blood pressure (Liehr, et al., 1995; Umana, Ahmed, Matthew, Fraley, & Alpert, 2006). The mean average over different hours the underestimation was 20.11 mmHg and overestimation was 20.69 mmHg.

The time difference of arterial line insertion did not make any significant difference on discrepancy of IBP mean and NIBP mean.

After establishing the relation, difference and the limits of agreements of IBP and NIBP (systolic, diastolic and mean) possible clinical factors that might have influenced the discrepancy between the two measurements were investigated. These factors included: Inotropic/ vasopressor support, sedation/analgesia, mechanical ventilation with PEEP and severity of illness (APACHE II score) **(refer to table 4.5**).

In this study as found in the discussion of the results in chapter four, it was found that none of the above clinical factors (Inotropic/ vasopressor support, sedation/analgesia, mechanical ventilation with PEEP and severity of illness (APACHE II score)) influenced the difference and the discrepancy between the two blood pressure measurements techniques (IBP & NIBP).

It was found instead that factors such as cuff sizes, arm position, or arm movement, quick deflation of cuffs, peripheral vascular diseases, presence of arrhythmias, pain, restlessness, during the measurement of the blood pressure were some of the contributing factors to high discrepancy of IBP and NIBP (Bur et al, 2003 ; Marks & Groch, 2000; Mourad, Carney, Gillies , Jones, Nanra & Trevillian, 2003; ; Rastam, Princas & Gomez-Marin, 1990; Thomas, et al,. 2002; Wittenberg, Erman, Sulkes, Abramson & Boner, 1994).

Regarding the reasons of admission in the five critical care units, Medical, elective surgery, coronary care, neuro and emergency surgery. The limits of agreement of elective surgery patients were a bit higher compared to others of about 11mmhg most probably because of high levels stress and pain after surgery.

In part two of this study was to elicit the reasons given by clinical practitioners for choice of blood pressure monitoring techniques in the critical care unit. The reasons given by the 80% participants were that IBP measures the core arterial blood pressure beat by beat which is in line with most of the studies and believe that it is traditionally known as accurate method of blood pressure measurement (Jeff, Clark, Lieh-lai, Sarnaik, Mattoo, Ashok & Mary, 2002).

In this study, 20% (n=10) clinical practitioners preferred NIBP over IBP. Their reasons were that with the shortage of skilled nurses and understaffing of most of the CCUs nurses do not have enough time to take care of the invasive lines, to make sure that they are not kinked, or well dressed, some respondents argued that some of the nurses do not know how to calibrate and zero in order to get accurate IBP therefore it is safe to use NIBP as it requires less skill and time.

When it comes to which method of blood pressure was easiest to use the majority of respondents 92% (n=46) clinical practitioners agreed that once the IBP is in situ, leveled, calibrated and zeroed it is the most easiest method to measure the blood .

5.4 LIMITATIONS OF THE STUDY

- Generalization of the findings from this study is not possible due to the contextual nature, and small sample size. Due to lack of sufficient subjects, lack of proper cuff sizes, and other equipments, only 80 patients were included in the study. The small size might contribute to the lack of significant results from this study. Endacott and bott (2005:53) have reported that inadequate sample sizes may result in failure to detect clinically important small to moderate effects of interventions.

- The fact that only one academic hospital was used. A large number of patients and clinical practitioners from more hospitals could make possible to generalize the results of the study.

- Using specific brands of hemodynamic equipments, different results or outcome may be found if different hemodynamic monitoring equipment brands are used.

- In this study, inotropic and vasopressor support did not have influence on the discrepancy of the two blood pressures (IBP &NIBP) according to literature, most probably due to the small dosages of inotropic and vasopressor support that were

ranging from 0.02 to 0.09 micrograms of adrenalin and 0.3 to 0.7 micrograms of phenylephrine. Different findings could have been found if big dosage were given.

- The data collection instrument of this study was developed by the researcher. It was being used for the first time and needs to be reviewed for future studies on blood pressure.

- The accuracy of IBP and NIBP findings are affected by various factors. The impact of some of these factors was reduced through the implementation of reliability and validity checks .Despite this, different results may be found if the study is carried out in other environments.

5.5 CONCLUSION

In conclusion the purpose of this study was to describe and compare the two blood pressure techniques IBP and NIBP in order to assess the limits of agreement between the two blood pressures obtained on patients in the adult critical care unit in a tertiary health care institution, to determine the difference in terms of accuracy and sensitivity, to determine the factors that affect accuracy of both techniques as well as to describe the reasons given by practitioners for their choice of blood pressure monitoring technique. By establishing the circumstances in which confusion between IBP and NIBP can be controlled, assessing and establishing the limits of agreements between the two measurement techniques for better clinical practice in decision making in CCUs.

With the current global economic recession the other goal was to see how one measurement technique can be used in order to reduce the ever escalating cost in CCUs when two monitoring techniques are in use simultaneously and interchangeably.

At the 95% confidence interval, the limits of agreements were found to be in range of ± 35 mmhg of IBP and NIBP systolic, ± 19.5mmhg of IBP and NIBP diastolic and ±19.3 mmhg IBP and NIBP of mean arterial pressure. In practical terms this means that IBP and NIBP can not be used interchangeably in CCUs during the first 48hours of arterial line insertion and patients aged between 18yrs and 50yrs as the two methods did not consistently provide similar measurements because there was a high level of disagreement that included clinically important discrepancies of more than 10 mmhg which is the cut off acceptable reference in terms of discrepancy between the two techniques IBP and NIBP.

In the second part of the study, the majority of clinical practitioners, more than 80 % of the sample acknowledged that the IBP technique remains the gold standard and reliable technique to measure the blood pressure as long as the catheter is patent and the transducer system is properly set up and functioning, the IBP technique measures the blood pressure beat to beat in the artery which is the amount of force exerted by circulating blood over a specific area, while cuff pressures NIBP measure flow, the amount of blood circulating over specific time (Campbell, 1997).

Variables such as Inotropic/ vasopressor support, sedation/analgesia, mechanical ventilation with PEEP and severity of illness (APACHE II score) ($p>0.05$) did not show significant influence on the discrepancy, instead reasons such as cuff sizes, arm position, or arm movement, quick deflation of cuffs, peripheral vascular diseases, presence of

arrhythmias during the measurement of the blood pressure, IBP measurement techniques came to the fore.

This knowledge can influence critical care practice pattern, with accurate and prompt decision making regarding blood pressure monitoring in critical scenarios and in turn aid in reducing the hospital and patient costs involved, providing better patient care because the goal of nursing research is to influence better practice.

5.6 RECOMMENDATION ARISING FROM THE STUDY

With the increasing severity of illness and nature of complexity of CCU patients, rapid advancement in critical care monitoring technology and ever growing confusion in IBP and NIBP, CCU nurses and management need to develop a comprehensive clinical guideline in order to render care based on the complex needs for better patient outcome in CCUs. In order to meet these patients' complex needs, the following recommendations have been made for the benefit of the following four disciplines.

5.6.1 Recommendations for Clinical Nursing Practice

- The critical care unit managers must emphasize the benefit of justifiable decision making based on patient assessment regarding hemodynamic status of the patient, this can be implemented via regular audits by critical care unit managers whereby critical care nurses are required to justify the discrepancy of IBP and NIBP in relation to general condition of the patient and physical assessment findings in decision making. This recommendation is supported by the call towards evidence-

informed critical nursing whereby it is no longer acceptable for critical care nurses to base their decision of care and intervention on rituals and tradition; they must be able to justify the decisions they have made about appropriate care and treatment on basis of evidence based expertise (McSherry, Simmons & Abbot, 2002).

- Due to the discrepancy existing according to these findings the institutions should consider using only one BP technique in the critical care setting or to put in place clear clinical guidelines regarding the agreement between IBP and NIBP in order to help decision making without unnecessary delay.

- Escalating cost is of a great concern to hospital managers, medical aids and critical care managers. Critical care nurses involved in direct patient care are in the best position to reduce costs incurred when they use unnecessary different techniques while measuring one parameter (blood pressure).

5.6.2 Recommendations for Nursing Education

The following recommendations are made for nursing education.

- Clinical instructors and nurse educators should use learning opportunities in CCU to ensure that nurses understand the hemodynamic monitoring technology including IBP and NIBP in all aspects in order to comply with the equipments manufacturer's guidelines and all technical procedures regarding measurement of IBP and NIBP. Apart from knowing how to set up and monitor IBP technique, critical care nurses should also know how to interpret IBP arterial waveforms in order to ensure its accuracy.

- Critical care nurses should be educated on common problems associated with the arterial line waveform like ovedamping and and underdamping and the reasons for these artifacts.

- Education on accurate BP cuff size, since using a cuff that is too small will lead to falsely high reading and using cuff hat is too large will lead to false low readings.

- Nurses should know that a cuff width selected should equal 40% of the arm circumference, appropriate cuffs sizes based on upper- arm circumference should be followed.

- In order to facilitate justifiable decision-making in clinical practice rather than routine usage of two monitoring techniques IBP and NIBP nursing educators should lay emphasis on critical thinking skills in both basic and advanced nursing education.

- In continuing nursing education programs based on the needs of critical care nurses, critical care unit managers and administrators could perform appraisals to determine the critical care nurse's knowledge and expertise regarding the agreement of IBP and NIBP techniques over a given period of time in order to establish knowledge deficits and misconception regarding agreement of IBP and NIBP . In this way, nursing education will be based on the established needs of critical care nurses.

5.6.3 Recommendations for Further Research

Further research is recommended to investigate the following issues which arose from the study:

- This study could be extended to include other age categories adult and children in different hospital CCUs in South African public and private hospitals.

- A more detailed investigation on discrepancy of IBP and NIBP on a bigger sample size is still needed.

- In this study, inotropic and vasopressor support did not influence much on the discrepancy of the two blood pressures (IBP & NIBP) most probably due to small dosage of inotropic and vasopressor support that was ranging from 0.02 to 0.09 micrograms of adrenalin and 0.3 to 0.7 micrograms of phenylephrine. However other studies are needed in the future with patients on big dosages of inotropic/vasopressor in order to shed light on its influence on the two blood pressures techniques. The same will apply on sedation and analgesia.

- The data collection instrument of this study was developed by the researcher. It was being used for the first time and needs to be revised for future studies on blood pressure monitoring to make future research easier.