CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Currently, cost reduction in many of the private and state hospitals has become a common concern as most of the critical care units (CCU) function as business units. There is a great challenge on health care institutions to cut down cost. The utilization of two blood pressure methods that are conflicting and have high levels of discrepancy with lack of good protocol and guidelines is being under the microscope as a way of contributing to critical care unit costs, which is already high. The confusion on which of the two blood pressure measurement techniques should be used in the decision making is still ravaging many critical care nurses across the globe. This is heightened in a situation whereby until now there is no good guideline or written protocol as to which blood pressure technique to use on a daily basis for safe critical care nursing practice.

Many studies have been carried out to compare the two methods of invasive blood pressure (IBP) and non invasive blood pressure (NIBP) (Araghi, Bander & Guzman , 2006; Dubin, Mignini & Piacentini, 2005; Gregory, Janelle & Gravenstein, 2006; Clark, Mary, Lieh-Lai, Jeff, Ashok, Sarnaik, Tej, Mattoo, 2002; Mary, McCann, Hill, Kristin, Thomas, Zurakowski & Laussen , 2005; Pytte, Dybwik, Straume & Nielsen, 2006) However no study on assessing and establishing the limits of agreement of these two measurement methods has been carried out in South Africa. Furthermore, there is a need to see how only one measurement technique can be efficient and reliable for decision making in the critical care setting in order to render a quick and efficient care to the patients in the critical care units, as well as curbing the exorbitant costs in all critical care units.

This literature review will assess the limit of agreement between IBP and NIBP in terms of the technical aspects of the monitoring devices, their application in practice, the nursing implications involved in their use and more importantly to shed light on accuracy and reliability of each of the measurement technique in critical care settings.

2.2. OVERVIEW AND PHYSIOLOGY OF BLOOD PRESSURE

Blood pressure is the force put on the walls of the blood vessels with each heart beat, which helps to move or circulate blood through the entire body. Blood pressure has two important components namely the systolic and the diastolic. Systolic refers to time when the heart is fully ejecting blood and diastolic refers to the resting phase of the heart. (Chlochesy, Breu, Cardin, Wittaker & Ruddy, 2000). Blood pressure is a critical component of a person’s vital signs and it is a basic parameter for nurses in physical assessments of patients. It enables evaluation of a person’s cardiovascular state and selection of appropriate interventions. (Thomas, Liehr, Dekyser, Frazier & Friedman, 2002).

2.2.1 Blood Pressure Monitoring in the Critical Care Unit

Blood pressure monitoring is a central component of critical care. It is the cornerstone of patient management as it suggests cardiogenic, hypovolemic, obstructive or distributive etiologies to cardiovascular insufficiency, thus defining the specific treatments and interventions required and it allows one to monitor the response to therapy. Blood pressure monitoring indicates the patients’ status to guide nursing practice and decision making in the critical care settings. (Pinsky & Payen, 2005; Polanco & Pinsky, 2007; Thomas, et al., 2002). There are currently two techniques to measure blood pressure in the critical care unit, namely invasive blood pressure and non invasive blood pressure as will be discussed below.

2.3 INVASIVE BLOOD PRESSURE MONITORING

Patient management in critical care and emergency care is guided by measurement of systolic, diastolic and mean blood pressure. Often direct reading namely invasive blood pressure from the radial artery is used mainly because it is considered as the gold standard technique for its accuracy and reliability during emergencies and critical situations (Dubin, et al, 2005). (In this study only measurements from radial artery were considered)

The first recorded invasive blood pressure measurement was in 1733 by Reverend Stephen who spent many years recording the blood pressure of animals. He took a horse and inserted a brass pipe into its artery; this brass pipe was connected to a glass tube. He observed the blood in the pipe rising and concluded that this must be due to pressure in the blood (The history of blood pressure measurement , www.medphys.ucl.ac.uk/teaching/undergrad/projects/2003/group_03/history.html) Unknown author accessed on 31/05/2008.

It was not until 1847 that human blood pressure was recorded by Carl Ludwig's kymograph with a catheter inserted directly into the artery. Ludwig's kymograph consisted of a U shaped manometer tube connected to a brass pipe cannula into the artery. The manometer tube had an ivory float onto which a rod with a quill was attached. This quill would sketch onto rotating drum hence the name ‘kymograph’, wave writer in Greek (www.vasotrac.com/medhistbp.htm) Unknown author, accessed on 31/05/2008

It is from Ludwig’s discovery that many pioneer physicians continued to develop more accurate and reliable invasive blood pressure measurement techniques that we have today. These techniques consist of direct transducing of systemic arterial blood pressure with the computer assisted cannulation of automatic mean arterial pressure, diastolic pressure and systolic pressure during each heart beat. It is basically connected to a disposable pressure transducer using 100m long tubing. Air bubbles are carefully flushed out of the system before the reading of blood pressure. The zero level for the arterial blood pressure is taken at the right atrium at the fourth intercostals, mid axillary line; the zeroing negates the effects of atmospheric pressure so that only pressure values that are measured are the ones within the blood vessel or within the heart in order to ensure accuracy in blood pressure reading.

The blood pressure waveform is displayed on the monitor displaying good diastolic, systolic and, diacrotic notch which are transduced through digital figures of diastolic, systolic and mean blood pressure (Gardener, 1992). The calibration is checked against a mercury column, the fast flush technique as described by Gardener is performed to reduce the risk of air bubbles, dampened wave forms, inaccurate readings prevent fluid leaks and reduce risks of infection. The flush solution is put in pressure bag with heparin and pumped up to 300mmhg to maintain flush device which will deliver three mls per hour to ensure that the arterial line remain patent and free occlusion. (Bur, et al, 2000)

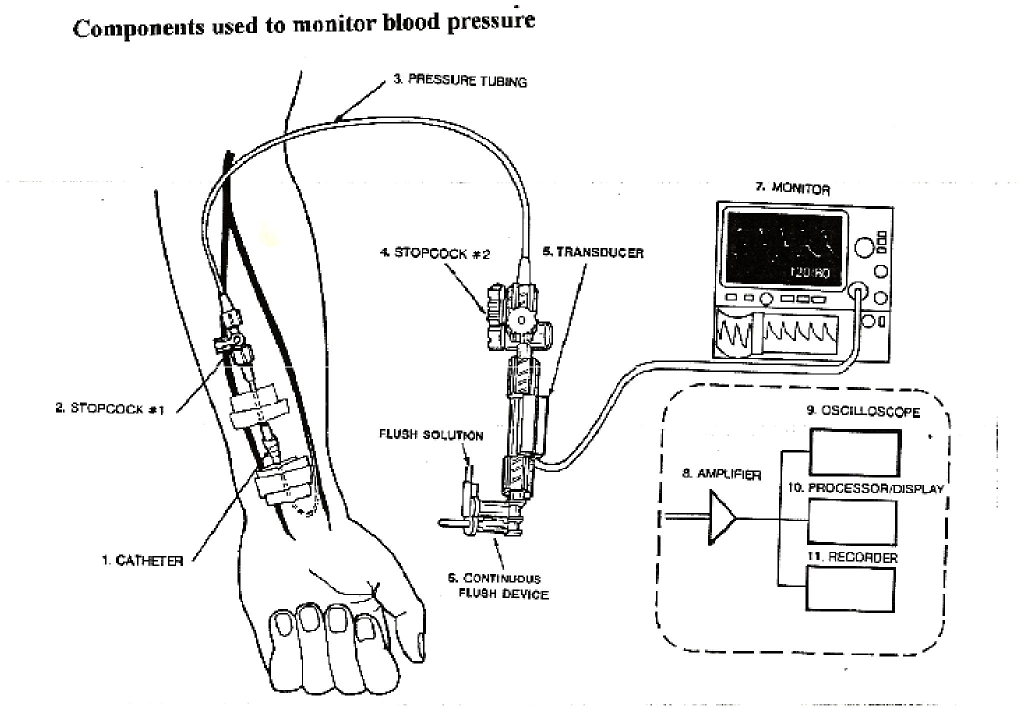

Figure 2.1 Diagram and set up of invasive blood pressure measurement (Mcghee & Bridges, 2002)

2.3.1 Advantages of Invasive Blood Pressure Measurement

The arterial indwelling catheter for the purpose of arterial invasive blood pressure monitoring is an invaluable tool for providing continuous monitoring of systemic blood pressure as well as serving as convenient site for multiple bloods sampling of patients in the critical care unit (Frezza & Mezghebe, 1998). The invasive blood pressure monitoring has a distinct advantage, as it is the only scientifically and clinically validated method that allows real-time and continuous monitoring of patients' arterial blood pressure. With strip-chart recording, beat to beat analysis of patient's arterial blood pressure is possible. This feature may be of clinical relevance when evaluating the effect of positive end-expiratory pressure during mechanical ventilation or the effect of changing stroke volume in atrial fibrillation or other arrhythmias. (McGhee & Bridges, 2002)

2.3.2 Disadvantages of Invasive Blood Pressure Measurement

During the insertion of a radial arterial catheter, a lot of errors may occur especially if the patient is restless or confused where the catheter may be dislodged. Due to the high frequency of drawing blood for arterial blood gases (ABG) or for any investigative purposes by an inexperienced nurse, the arterial line may block due to ineffective heparin saline flushing system, air bubble in the system, damping, overdamping, underdamping, incorrect leveling of the transducer. All of these might contribute to the diminished shape of arterial waveform or total loss of waveforms that might lead to false blood pressure measurements (Frezza & Mezghebe, 1998; McGhee & Bridges, 2002; Yazigi, Madi-jebara, Hayet, Jawish & Haddad, 2002).

The cannulation of an artery is associated with so many problems that can affect the integrity and accuracy of the blood pressure measurement. These complications are like osler node formation, pseudo aneurysm formation thrombosis at the site of catheterization and sepsis like nosocomial infections that take advantage of every vascular puncture. There is vascular insufficiency in some instances, loss of limb or digit is reported, survey of chronic ischemia and embolectomy or forgarty thrombectomy.

Literatures of Frezza & Mezghebe, (1998); Lodato & Schlichting, (1998) have documented persistent obstruction of the radial or ulna artery by angiography Doppler ultrasonography after the insertion of the arterial catheters, but these findings rarely result in clinically significant of chronic ischemia. Bleeding is the second most common complication after vascular insufficiency, others have reported high incidence of haematomas 9.3%. Some of these patients are on anticoagulants like warfarin, clexane, disprin, plavix, ecotrin, heparin infusion and some of them are in disseminated intravascular coagulation (DIC) (Frezza & Mezghebe, 1998; Lodato & Schlichting, 1998).

2.4 NON INVASIVE BLOOD PRESSURE MEASUREMENT

As an alternative method of these various complications and artifacts of invasive arterial blood pressure measurement, as described by Bur, et al., (2003), the oscillometric non-invasive blood pressure method is simultaneously or interchangeably used along with the invasive blood pressure.

This non invasive blood pressure measurement technique is based on the principles discovered by a Russian Surgeon Dr Nikolai Korotokoff in 1905. His major efforts were to find reliable clinical signs that could predict whether limb flow would be viable after vascular surgery of traumatic aneurysm. He found that after complete compression, the aneurysm of the arm (i.e. distal pulse on brachialis) disappeared with Riva-Rocci cuff and then gradually decreasing the pressure, a series of sounds could be heard by stethoscope under the artery distal of the compression. He described four distinct phases of sounds: first sound, the compression murmurs, second tone and disappearance of sounds (Kortokoff, 1910; Paskalev, Kircheva & Krivoshiev, 2005; Segall, 1965; Yury, Shevchenko, Joshua & Tsitlik, 1996).

Due to intensive advance in medical technology, automated oscillometric devices for non invasive blood pressure monitoring have become the standard, replacing the stethoscope and sphygmomanometer in hospitals, thus eliminating the challenge of hearing and recording Korotkoff sounds (Schell, Lyons, Bradley, 2006). But the Korotokoff sounds discovery has been the basis of automated oscillometric method of non invasive blood pressure measurement that we use now, in which an inflated cuff around the patients' arm compress the artery, the pulsatile arterial blood flow causes oscillations superimposed on the cuff pressure. As the cuff progressively deflates, the magnitude of the oscillation as function of the cuff pressure increase until the mean arterial pressure is reached. The minimum amplitude of arterial blood pressure oscillation is identical to the mean arterial pressure, the oscillation magnitude decreases. The systolic, diastolic measurements are deduced from the oscillometric signal by extrapolation result from empirical values, the procedure is microprocessor controlled (Bur, et al., 2003; Schell, et al., 2006).

2.4.1 Advantages of Non Invasive Blood Pressure Measurement

It is non invasive, that means less risk of nosocomial infections, sepsis and bleeding. It saves time as it is easy and quick to use, with minimal challenges. It is less expensive, therefore contributes positively in the reduction of critical care cost. It is portable and no need to calibrate or to transducer.

2.4.2 Disadvantages of Non Invasive Blood Pressure Measurement

There is an increase of inaccuracy in non invasive blood pressure monitoring mainly because of cuff sizes, level of anxiety like movement during the blood pressure reading, state of muscular relaxation effects of inotropes and peripheral vasodilatation, position and leveling in relation to the heart.

The selection of proper arm cuff is important because it is widely known that a smaller cuff gives a false high blood pressure and a larger cuff also gives a false low blood pressure reading.

Jeff, Clark, Mary, Lieh-Lai, Ashok, Sarnaik, Tej, Mattoo (2002) revealed that a majority of healthcare providers do not follow the provided guidelines of cuff size selection, in a recent editorial in blood pressure monitoring, Alpert (2000) said from practical experience that improper cuff size is used at least 30%-50% of the time. In a study from Britain, Wingfield, Pierce, Feher (1996) reported that only 27% of Doctors and 32% of nurses correctly estimate the appropriate coverage of the upper- arm with blood pressure's cuff as per published British guidelines.

The problem regarding cuff size selection relates both to the lack of knowledge of healthcare providers on the current recommendations and to the recommendations themselves. The study by Bur, et al (1996) and Wittenberg, Erman, Sulkes, Abrahamson & Boner (1994) revealed that arm cuffs by 2/3 and 3/4 upper arm length criteria, a significant difference exists between the ideal and the actual cuff sizes that were used for blood pressure measurement. The actual cuffs were significantly smaller than ideal and this was attributable perhaps to a limitation of choice beyond the large adult cuff size. On the contrary the difference was not significant when 40% upper arm circumference criterion was used. This was a result of greater choice among smaller cuffs which allowed selection of a cuff very close to the ideal size. The anthropometric data in patients including gender distribution, age, body mass index (BMI), upper arm length and upper arm circumference were within normal range.

The study also revealed that arm cuffs by 2/3 and 3/4 of upper arm criteria give significantly lower systolic blood pressure when compared with direct radial arterial blood pressure. The difference is not significant when 40% of upper arm circumference criteria is used for cuff selection. For diastolic blood pressure, the upper arm length cuffs significantly underestimated radial artery diastolic blood pressure, whereas upper arm circumference overestimated radial artery diastolic blood pressure. These observations indicate that by using the current task force cuff size recommendation of 40% upper arm circumference, the indirect non invasive blood pressure measured matches with the arterial invasive blood pressure but not with the diastolic blood pressure.

Rastam, Princas, Gomez-Marin, (1990) reported that as arm cuff size increases, blood pressure decreases until the cuff width is approximately equal to 40% of the upper arm circumference.

In a recent study, in the adult critical care unit, Marks and Groch (2000) compared indirectly measured blood pressure using cuff width of 30-55% of upper arm circumference to radial intra arterial blood pressure in the contralateral arm they found that there was not a single proper cuff width /arm circumference ratio that was in all patients. As arm circumference increased the optimum ratio decreased. For the group as a whole, a cuff width/arm circumference ratio of 46% produced no errors when comparing intra-arterial and systolic blood pressure on the basis of extrapolation, they determined that a cuff width / arm circumference ratio of 74% would produce no errors when comparing intra-arterial to cuff diastolic blood pressure the findings that a larger cuff than 40% upper arm circumference is necessary for accurate measurement of diastolic blood pressure is in agreement with these results.

The study concluded that the current repertoire of commercially available arm cuffs is inadequate when using upper arm length as cuff selection criteria. Longer arm cuffs are required for blood pressure measured by upper arm circumference criteria. Furthermore indirect blood pressure measurement by the current task force recommendation of 40% upper arm circumference is compatible only to systolic and not diastolic arterial blood pressure. It is still not clear whether additional cuff sizes or alternative selection criteria would single out the cuff that is accurate for measuring systolic blood pressure as well as diastolic blood pressure. (Araghi, et al., 2006; Jeff et al, 2002)

Even though many studies showed that the oscillometric blood pressure (NIBP) underestimates the invasive arterial blood pressure and exhibits that a high number of measurements are out of the clinically acceptable range, many blood pressure measurements don’t achieve adequate accuracy needed in critically ill patients, and that might put a critically ill patient in irreversible complications.

In addition, the above also demonstrate that the relationship between the cuff and the upper arm circumference contributes substantially to the oscillometric non invasive blood pressure measurements. Another disadvantage of the oscillometric method is that every manufacturer develops the standard empirically and no generally accepted and standardization of its measurements and evaluation exists (Bur, et al 2000; Jones, Appel, Sheps, Lenfant & Roccella, 2003).

2.5 COMPARISON OF DISCREPANCY BETWEEN INVASIVE BLOOD PRESSURE AND NON INVASIVE BLOOD PRESSURE MEASUREMENT

McGhee and Bridges (2002) argue that no absolute relationship exists between these two blood pressure measuring techniques because they follow different laws of physics and physiology. Invasive blood pressure monitoring measures pressure pulse, whereas noninvasive blood pressure monitoring is related to blood flow in low flow condition such as hypotension and vasoconstricted states. Non invasive method yield lower pressure readings than does invasive monitoring. Conversely, if systemic vascular resistance (SVR) is low in patients with sepsis for instance, the relatively high flow results in noninvasive blood pressure that is higher than invasive measured blood pressure.

Factors such as underdamping, end-hole artifact, and wave reflection contribute to invasive systolic pressure readings that are often higher than non invasive obtained pressure values. Mean arterial blood pressure of both techniques are closely approximated when IBP and NIBP measurements are compared, because it is least affected by monitoring method, catheter insertion site, the dynamic response characteristics of the catheter system, and wave reflection (McGhee & Bridges, 2002).

When data obtained by using noninvasive methods are compared with invasive recordings which are considered as the gold standard, it must be kept in mind that invasive blood pressure may be less accurate than expected, given the unavoidable distortion related to fluid-filled catheter and transducer characteristics. The NIBP measurements are known to underestimate the invasive systolic blood pressure (SBP) and the discrepancy between the two methods is minimized when smaller cuffs size than recommended were used (Chelma, Denis, Teboul, & Richard, 2008). The severity of illness also increases the discrepancy between these two blood pressure techniques.

Different authors (Araghi, et al., 2006; Bur, Herkener, Vlcek. et al 2003; Chelma et al 2008; Pytte, et al., 2006) agree that the possibility of making incorrect clinical decision based on blood pressure measurement increases with the discrepancy of the two methods. They concluded that a discrepancy of >10mmhg in critically ill patient, is considered relevant and acceptable, but the discrepancy between NIBP and IBP measurement that is greater than 10mmHg is irrelevant and unacceptable, and could lead to improper treatment such as unnecessary vasopressor therapy or failure to start such treatment. The authors concluded therefore that IBP monitoring must be preferred over NIBP when critical decisions are required. In hemodynamically stable patients, valuable information may be obtained by using noninvasive blood pressure monitoring technique.

Figure 2.2 Example showing the discrepancy of invasive and noninvasive blood pressure measurement in critical care unit. Unknown author accessed on 22/05/2008 **(www.icu-usa.com/tour/procedures/bp.htm)**

2.6 NURSING IMPLICATIONS

Critical care nurses process a vast amount of patient care data after making frequent therapeutic changes in management and consequently making decisions that have significant implications on the prognosis of critically ill patients (Hicks, Merrit & Elstein 2003). Monitoring of IBP and NIBP cannot be done single-handedly without other investigations such as central venous pressure (CVP), hemoglobin (Hb), urine output and the general condition of the patient. This therefore requires the linking of information from the various sources in order to come up with a clear picture of a patient's status and consequently validate the indicators from the monitoring techniques and interventions that will be implemented thereafter. This has several implications for nurses with regard to the technical aspects and applications of the two blood pressure techniques in the critical care setting. (Polanco & Pinsky, 2007)

The two blood pressure techniques are currently still being used simultaneously and interchangeably without policy, protocol or scientifically based reasons. This often leads to starting treatment unnecessarily or denying treatment to the patient when he actually needs it. Due to this malpractice, some of the patients may loose their lives, or stay unnecessarily longer in the critical care unit. This infringes on the patient's right and is against the nurse's Scope of Practice.

The South African Nursing Council regulation number 2598 (1991) stipulates that the nurse is responsible for the supervision over and maintenance of oxygen supply, fluid, electrolytes and acid base balance on the patient under his / her care. Searle (1994) also in her interpretation of the Scope of Practice states that a nurse must give treatment and care to the patient, and the administration of medicine, including the monitoring of the vital signs both IBP and NIBP and his/her quick reaction to abnormal data, disease conditions, trauma, stress, anxiety, medication and treatment. The nursing Scope of Practice therefore mandates the critical care nurse the responsibility and flexibility of performing and monitoring IBP and NIBP.

The South African Nursing Act (RSA, Act No.33 of 2005) highlights the rights of patients with special needs, like unconscious patients in critical care units that have rights to proper and accurate monitoring, carefulness and promptness according to their specific needs (Seale, 1994; SANC, Regulation Relating to the scope of practice of person‘s Who are registered or Enrolled Under the Nursing Act 1978. Regulation 2598)

The above authors stated that the critical care nurses should know the advantages and limitations of the invasive and non invasive blood pressure monitoring techniques used in the critical care unit in order to optimally render safe, and good nursing care. That’s why more efforts, resources and time must be invested in innovative, means and ways to render various available techniques to minimize bias and errors in measurements, artifacts and other physiological aspects that might affect the integrity of blood pressure measurements in the critical care setting.

Thomas, et al., (2002) acknowledged that advances in technology and data analysis have increased knowledge of the dynamic nature of blood pressure but recognition of the complex nature of blood pressure has not progressed rapidly over the last two decades, therefore there is a need for more research in this area as there are still many confusions in terms of which blood pressure measurements should be the cornerstone and basis of intervention in critical care units between the IBP and NIBP. Mostly this confusion and errors are orchestrated by so many aspects, like the structure of the vascular system that changes over time and with repeated hypertensive episodes, overweight, resulting in restructuring or hypertrophy of the arterioles that in turn causes an increase in vascular resistance resulting in hypertension. The thickened vessels with decreased lumen size result in higher blood pressure being maintained even with normal sympathetic stimulation (Julius & Nesbit, 1996).

2.6.1 The Role of Clinical Assessment

Monitoring in the critical care unit is very dynamic and there is a risk of focusing on the various monitoring devices rather than on the patient. Place (2000) states that assessing the cardiac output (warmth of peripheries, strength of peripheral pulses, color of the skin, tongue, Allen's test, urine output and central venous pressure of the patient can clinically give an indication of what extent the blood pressure reading is true or false. So if one of the blood pressure measurements is giving a false reading one should rely on the clinical judgment from the linking after the general assessment.

Many manufacturers and researchers have laid emphasis on the need for patient rigorous clinical assessment in the use of any monitoring device and before taking any drastic decision on therapeutic intervention. Although scientific and technical monitoring in the critical care unit is crucial, one should not loose sight of clinical assessment and focus on the machines and devices only, instead of physical and general assessment.

2.7 APPLICATION OF IBP AND NIBP

Non invasive blood pressure and invasive blood pressure techniques are widely used in a variety of CCU settings. These two techniques should be performed by a trained individual as they require much attention due to different technical aspects that might give wrong results and further discrepancies. In practice, different healthcare professionals including the critical care nurses who may know the technical aspects of how to use the machines, monitor, bridge, transducers, and all components of both techniques and who can interpret the information or make a critical decision based on the information may only be assigned to look after those patients with sophisticated, advanced monitoring devices for patients safety.

The arterial line for invasive blood pressure monitoring can be inserted in many places but radial artery is widely used due to its easy accessibility and has less complications of bleeding as it is smaller than the femoral or brachial artery (Arnal, Garutti, Perez-Pena, Olmedilla & Tzenkov, 2005; Jeff, et al., 2002). The cannula is inserted in the left or right radial artery, a study by Zwirn, Burnet and Barthelemy (1991) shows that there is no difference using the right or left arm provided that there is no known or existing peripheral vascular diseases.

The arterial catheter is normally inserted by a doctor but prepared by a critical care nurse. Air bubbles are carefully flushed from the system before the blood pressure (BP) reading is considered as true reflection. Allen‘s test is performed to rule out peripheral vascular insufficiency. The critical care nurse helps the physician with the procedure by supporting the patient’s hand and dorsi-flexing the wrist. The critical care nurse places air fluid interfaces of the transducer system at the level of phlebostatic axis levels and zeros the transducers at the atmospheric pressure at least every four hours or as needed depending on the patients’ status. The critical care nurse identifies the normal arterial waveform, various physiologic effects and trouble shooting as necessary.

It is advised always to compare arterial blood pressure with the non invasive blood pressure if there are any doubts although the objective of this study is that the comparison of the non invasive blood pressure with invasive blood pressure, always leads to confusions especially if there are a lot of discrepancies (Jeff, et al., 2002). After the procedure the nurse should assess the pulse, colour, sensation, and temperature distal to the insertion site every two to four hours. The skin is also observed at the site and distally for blanching during irrigation, changes in the flush solution, tubing and dressing in accordance with local infection control guidelines and always using the aseptic techniques when handling the system. Signs of infection should also be inspected (Bur, et al., 2003).

It is advised that only an experienced critical nurse should be allowed to draw blood through the arterial lines (Frezza et al., 1998).

The arterial indwelling catheter is a valuable tool for providing continuous monitoring of systemic blood pressure as well as serving as a convenient site for multiple bloods sampling of patients in critical care units. The authors Frezza, et al., (1998) in their literatures stipulated that with appropriate insertion technique and catheter care it has been suggested that complications can be kept to a minimum. The incidence of vascular insufficiency can be minimized by performing Allen's test (checking of blood supply on fingers and nails) prior to arterial catheter insertion and using Seldinger techniques. Line patency can be maintained by flushing the arterial catheter with either heparinised normal saline solution or normal saline after every use (Frezza, et al., 1998).

It is very obvious that many times due to vascular conditions or patients being edematous, the physician finds it difficult to insert a good reliable patent arterial line. In many occasions during the data collection, the researcher realized that heparinised normal saline solution for flushing had finished and the arterial line had not been flushed for a while and this causes the line to be occluded due to clots. It has also been realized that the pressure bag may also be faulty, as it deflates by itself and therefore it does not serves the purpose of pushing the heparin solution of three mls per hour as needed.

Frezza, et al., (1998) also found that vascular insufficiency is the most common complication in critical care units, the rates of thrombosis was higher in case of arterial change over the line than after a new line insertion. Exactly the opposite occurred for spasms and pulselessness in which there was a significant prevalence in cases which the catheters were newly inserted. A local pulse loss or clinically evident ishchemic injury occurred as a consequence of thrombosis, embolization or vascular spasm. Arterial dissection or rarely cholesterol emboli may have also led to arterial insufficiency.

The use of norepinephrine or adrenalin (vasoconstrictor) or any other vasodilator has an effect on non invasive blood pressure monitoring as many clinicians use non invasive blood pressure in following up septic patients because the radial pressure is damped or does not correlate with higher oscillometric pressures.

Pytte, et al., (2006) argued that disease severity significantly affects the differences in the blood pressure registered. This may be due to vascular changes often seen in septic patients that causes (vasodilatations) and increased blood flow. A similar discrepancy between NIBP and IBP has been reported in patients undergoing thermal vasodilation and general anaesthesia. The fact that the discrepancy between the two methods increase with increased disease severity implies that one should be careful in using only invasive pressure in monitoring vasopressin treatment in critically ill patients.

In South Africa the number of trained critical care nurses who are normally in charge of shifts and supervise other nurses has drastically decreased due to the mass exodus of critical care nurses to other developed countries. This has led to a compromise in the supervision by nurses who are not qualified as critical care nurses and do not have enough experience, skills and knowledge to use these blood pressure monitoring techniques to benefit the patient outcome. (Binnekade & De Haan, 2003). In the institution where the study was carried out, the teaching status aggravated the problem further by creating the need for more supervision of these inexperienced nurses.

The untrained critical care nurses and students work under varying degrees of autonomy with regard to monitoring the patient's blood pressure effectively, both invasive and non invasive, although the critical care nurse running the shift oversees the care that the individual nurses are rendering. Based on observations, it has been realized that physicians are commonly unaware of the charges for common diagnostic tests and sophisticated monitoring techniques. (Pelletier, 1995) Knowledge of the cost involved in sophisticated hemodynamic monitoring techniques will reduce the way and frequency that they normally utilize them, therefore reducing the cost (Cummings, Long & Hyrnkiewich, 1982; Tierney, Miller & Mcdonald, 1990).

In the critical care units where the research was carried out the nurses and doctors are not familiar with the cost involved with transducing equipment like heparin, deltran, canula, tubing, dressing and pressure bag. This is because in this public hospital the majority of patients pay a minimal fee for medical services and care due to government health care subsidy. In this case the nurses do not have to charge every single item used for the arterial blood pressure monitoring setup for the patients. A study by Muakkassa, Rutledge, Fakhry, Meyer, Sheldon, 1990, found that the presence of arterial line setup increases the number of blood samples including arterial blood gases accessed and these laboratory tests tend to increase the overall cost on patients in critical care units. In the study of blood loss in critical care units, Andreas, Watemon and Hillier (1990) excluded the patients who did not have the arterial blood lines. This exclusion criteria was supported by Muakkassa, et al., (1990) with the reason for the exclusion being that patients without the arterial lines tended to have fewer blood samples taken.

The number of days of admission in critical care units also has a negative impact on the number of laboratory samples done for various reasons. Vander-Salim and Blair (1984) found that reducing the number of days that the patient spend in the critical care unit after undergoing open heart surgery from two days rocketed the cost due to the number of tests that are drawn from the arterial lines.

As it can be seen that both monitoring techniques are of benefit to the patient despite having problems, errors and degrees of discrepancies between them. This is because they provide good information and data that help in managing critically ill patients according to their specific needs. However there is a need to have an understanding of the technology behind monitoring devices as well as interpretation of their data. This has several implications for a bright future in the critical care nursing practice.

2.7.1 Nursing Knowledge

In the critical care setting an effective use of IBP and NIBP monitoring, a sound knowledge based on technical aspects of blood pressure monitoring devices, mechanism, the information they provide as well as their advantages and limitations are of crucial importance. This knowledge in turn affects the way and the technique used for IBP and NIBP monitoring is done and the consideration of both findings when comparing or determining whether or not to use the two techniques simultaneously or interchangeably. Sound knowledge also determines the reliability of the reading obtained from the invasive and non invasive blood pressure monitoring, because the reliability and the validity of the findings is based on the use of devices according to the manufacturers recommendations and research findings.

In order to make sense of the figures and data that are provided by the two techniques of measurements and consequently make an appropriate decision, it is important to understand how to interpret the information, the mechanism of operation of the monitoring device and the manufactures guidelines. Lawrence and Johnson (2004) explain that understanding physiology will help the critical care nurses to treat and act in a manner that will enhance the positive patients' outcome and will be able to rely on one measuring technique and it will enable the nurses to treat the patient and not the numbers (blood pressure reading).

Consideration of some other parameters such as CVP, temperature, urine output, perfusion, blood flow to vascular beds and assessing the patient holistically will help and guide the critical care nurses about the information provided by the two blood pressure monitoring techniques (Thomas et al., 2002). Knowledge and the implementation of recommendations put forward by the manufactures with regard to the use of these two blood pressure monitoring techniques are essential for maximum utilization of these monitoring devices.

Blood pressure monitoring relies on a good functioning heart with a good after load, preload and contractility according to Starling's law (Fouche, 2001). So once the patients' cardiac condition is compromised then the end product measurements which are IBP and NIBP monitoring are likely to be affected. This is why blood pressure should be measured along with other parameters especially the pulse for the possibility of any arrhythmias, most commonly atrial fibrillation, ventricular fibrillation which affect the filling time of the heart and the cardiac output. (Currey et al., 2003).

A patient who has had cardiac pulmonary bypass tend to bleed postoperatively mainly due to heparin that was not well reversed or simply because of a vein or artery that was not properly closed, so critical care nurses should also consider why the blood pressure is low by checking the amount of bleeding in chest drains bottles or signs and symptoms of cardiac tamponade. In this case, blood transfusion is considered or auto transfusion if the surgeon decides to use the auto transfusion system. But first and foremost, the reason for the bleeding should be investigated and sorted out as urgently as possible (Chlochesy, Brew & Cardin, 2000).

The other issue on haemodynamic monitoring that often bring problems and wrong data reading is the use of inotropes namely adrenaline and phenylephrine on critically ill patients. The critical care nurse should know the effect of vasoconstriction on non invasive blood pressure monitoring and invasive blood pressure monitoring, It is very crucial that critical care nurse take into consideration the effects of these two drugs in case the blood pressure is too high, adrenaline should be weaned down and possibly vasodillation drugs like nitroglycerin (TNT) should be increased until the best mean is found (Pytte, et al., 2006).

Sepsis with high temperature is another factor that also affects the irregularity in both IBP and NIBP monitoring. It increases capillary permeability, causes leaking from intravascular compartment to extravascular compartment, decreases cardiac venous return, drops cardiac output and eventually drops the blood pressure (Bur et al, 2003; Chlochesy et al., 2000).

The arterial blood waveform on the cardiac monitor can be used to validate the reliability and validity of arterial invasive blood pressure monitoring (Bur, et al., 2003).

Many times, the limbs with the arterial catheter can get occluded and affect the arterial wave form. It is advised to always check the arterial wave form for the upper strock (systolic), the diacrotic notch and the down shape of diastolic BP, examine critically the waveform before considering the digital blood pressure readings.

Various manufacturers provide recommendations regarding the use of different components in invasive blood pressure monitoring as they provide different sizes of catheters for different ages. They also provide guidelines of the positions where these catheters are inserted, such as avoiding application of a cuff pressure on the same arm where the arterial catheter is inserted and avoiding insertion of another intravascular infusion line on the same line. Good equipment set up must be done effectively like zeroing the transducer, calibration, checking and optimizing the dynamic response characteristics. The risk involved in canulation including embolism, thrombosis, infection must also be avoided at all cost. Lundgren et al., (1993); Vivien, Griffiths and Philpot (2002) show that the incidence of phlebitis increases with the number of hours that the canula remains insitu. Both suggested that phlebitis increases to 65-75% when the catheter remains inside for up to 72hrs. A number of scoring systems have been designed to help the practitioner identify the various stages and severity of phlebitis (Jackson, 1998).

Richardson and Bruso (1993) also highlighted the risk of extravasation of fluid into the tissue, hematoma formation and high risk of incidence of thrombophlebitis and infection.

The critical care nurse should take care of these factors and risks and source of errors discussed above in order to increase accuracy of invasive blood pressure monitoring therefore increasing reliability and degree of confidence among clinical and critical care practitioners.

Protocol and guidelines should be drafted regarding the cuff size, the positions as it is also a controversial issue in critical care setting as it was found that smaller sizes causes high blood pressure readings while the bigger cuff sizes give low blood pressure readings. (Wittenberg, et al., 1994)

Protocols should only act as guidelines and not a blueprint, which should be followed blindly, consequently the use of a protocol still needs intensive work and research in order to get that sound knowledge based on all the aspects of technology in use as well as physiology involved in place for the effective use of the protocol and guidelines.

Nursing knowledge regarding IBP and non NIBP monitoring affects the pattern and ways they are used to influence patient progress outcome.

Decision making regarding which blood pressure measuring technique to use should be based on data from various sources including patients assessment of all aspects and components that affect the haemodynamic status, together with sound knowledge of the advantages of and limitations of the monitoring devices as well as the indications of monitoring techniques.

There is therefore a need for IBP or NIBP measurements guidelines based on research findings and recommendations so that they can be of practical benefit to critical care nurses who are faced with challenges and confusions.

Errors could result however from the insertion of a catheter, position, flushing pressure bag, occlusion of arterial line and kinking, inappropriate setup of arterial invasive monitoring techniques, malfunctioning cuffs, difficulty in getting the appropriate cuff size according to the upper arm circumference, and when the manufacturers' recommendations are not adhered to.

To avoid unnecessary costs, time and risk involved in setting up some of the techniques, critical care nurses together should view the context and severity of illness in order to determine which technique can be used instead of using all two simultaneously or interchangeably.

2.8 SUMMARY

This chapter dealt with literature review on IBP monitoring and NIBP monitoring in relation to the technical aspects of the monitoring devices, their application in practice and nursing implication involved in their use, factors linked to the usage of both IBP and NIBP measuring techniques in the critical care units have been addressed. Factors related to the use of non invasive blood pressure measurements have been addressed, the reason for the cost involved, the risks of extending patient's stay in critical care, confusion and time involved in using both measurement techniques have been evaluated.

The following chapter will deal with the research methodology.