CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

This chapter describes the method of data handling together with the approach used for analysis of the results.

At the end of the data collection period, the raw data was entered on a Microsoft Excel spread sheet. These data was set into the computer statistical package “STATA version 10” for windows and verified by the statistician.

Descriptive, comparative and inferential statistics were used to describe and analyze the results from the study in order to meet the study objectives, Descriptive statistics were used to characterize the sample used in terms of demographic variables and the method used to measure the blood pressure invasively or non invasively within 48 hours of admission to the critical care unit. Graphical techniques and simple calculations were used to determine the limits of agreement between invasive and non invasive blood pressure. Frequencies (f), percentages (%), range, mean and standard deviations (SD) were used where applicable to describe the data. Scatter plots, graphs and tables were used to present the study results for easier interpretation and understanding of the study outcomes.

The following statistical tests were used to analyze the data: Bland Altman, t-test and correlation coefficient test (r). Bland Altman is an analysis technique for examining the extent of the agreement between two measurement techniques, generally used to compare a new technique and on established one (Burns & Grove, 2003). In this study, Bland Altman was used to measure the agreement between IBP and NIBP in relation to what is clinically acceptable. The t-test is a parametric analysis technique used to determine significant differences between measures of two samples (Burns & Grove, 2003). In this study, the t-test was used to determine significant differences between IBP and NIBP. The degree of relationship between two measures (Burns & Grove, 2003). In this study, the degree of relationship between IBP and NIBP was indicated by using a correlation coefficient (r). A significance level of 0.05 (p=0.05) was decided upon for all statistical tests and all confidence intervals (CI) given are at 95% level. All totals are rounded to two decimal places. The research findings will be presented in this chapter.

4.2 APPROACH TO DATA ANALYSIS

Data analysis was done in five sections as discussed below:

The **first section** of data analysis involved the characterization of the patient's sample in terms of age, gender, reason for critical care unit admission, level of severity of illnesses (APACHE II score), co-morbidity and time of data collection after admission to CCU.

Section two of the data analysis involved the baseline assessment information and factors that influenced the relationship and discrepancies between invasive blood pressure and non invasive blood pressure, these included patients' heart rate, temperature, invasive blood pressure (SBP, DBP, MBP), non invasive blood pressure (SBP, DBP, MBP) mode of ventilation (PC, SIMV, SIMV/PS, PS), peak inspiratory pressure, pause inspiratory pressure, PEEP level, type and dosage of analgesia, type and dosage of sedation type and dosage of paralyzing agents including type and dosage of inotropic/vasopressor support.

The **third section** of data analysis aimed at determining the difference, relationship and limits of agreement between IBP and non NIBP measurements.

Bland and Altman's (1986) technique was utilized to determine the limits of agreement between IBP and NIBP measurement methods. In this technique a plot of the differences of IBP (systolic, diastolic, and mean) against their mean was calculated in order to investigate the measurement differences between IBP and NIBP measurement before 48hrs of arterial line placement. The limits of agreement were determined at 95% confidence interval level for differences within an individual. The summary of the plots are given in the form of Bland and Altman scatter plots and table formats.

For each selected set of IBP and NIBP readings, the mean difference (bias) was also determined. The paired t-test was used to determine the significance of differences between the means of the two sets of data (IBP and NIBP), using significance criterion of $p \leq 0.05$. The t- test was used because it is the most commonly used parametrical statistical technique for determining the significance of the differences between the means of two sets of data (NIBP and IBP) of interval strength as stated by (Brink, 2002).

The fourth section dealt with the comparison of the limits of agreement between NIBP and IBP to what is clinically acceptable in critical care units. According to current studies in relation to NIBP and IBP measurement, the discrepancy of less than 10 mmHg is clinically acceptable and the discrepancy of more than 10 mmHg is clinically unacceptable

(Chelma, Teboul & Richard, 2008; Pytte, Dyebwik, Sexton, Straume & Nielsen, 2007). The limit of agreement was done according to Bland and Altman's test (1986) whereby the difference of IBP was plotted against the mean of NIBP. The scatter plots were plotted separately and the summary of the results are presented in this section of the study in a table format. Confidence interval were calculated and compared with the 10 mmHg in order to get the number of BP measurements that were clinically acceptable and those that were unacceptable. The above four sections make **part one** of the study

The **fifth section** which is in **part two** of the study dealt with the opinions of different clinical practitioners working in CCU on these two methods of blood pressure measurements (NIBP and IBP).

4.3 RESULTS AND FINDINGS

Part one of the study in the assessment of the limits of agreement between invasive and non invasive blood pressure

4.3.1 Section One: Demographic Data

Age

Age groups of the participants in the five CCUs were as follows: Slightly more than half of the patients were between the age of 40-49 years representing 56.41% (n=44) of the sample .In this study 25.64% (n=20) of the patients were between the age of 30-39 years. The minority of the group was between 20-29 years representing 17.95 % (n=14) of the sample. Findings are summarized in **figure 4.1**

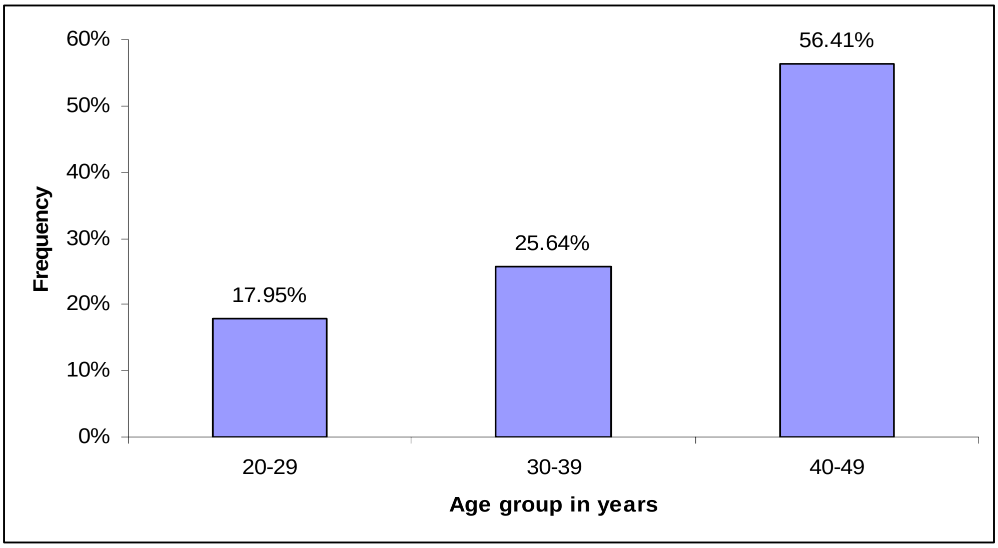

Figure 4.1: Age group of the participants (patients)

Gender

In terms of gender, the majority were male patients 62.03% (n=49) of the sample whereas the minority were female patients only accounting 37.97% (n=30) of the sample. One of the patients was not sexually coded. Findings are summarized in **figure 4.2**

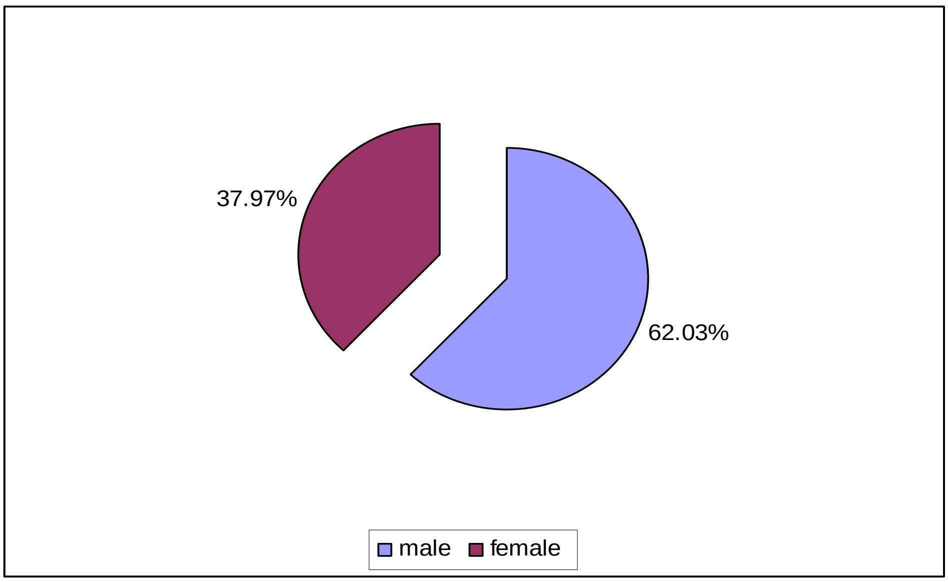

Figure 4.2: Gender of participants (patients)

Characterization of critical illness of participants

Table 4.1: Characterization of critical illness of participants (n=80)

Item	Demographic Variable	n=80	Percentage %
1.5	Reason for admission		
	- medical	24	30.00%
	- elective surgery	17	21.25%
	- emergency surgery	39	48.75%
1.6	Level of illness severity (APACHE II)		
	- 12-19	4	5.13%
	- 20-25	38	48.72%
	- 26-30	22	28.21%
	- 31-35	11	14.10%
	- 36-40	3	3.85%
1.7	Co-morbidity		
	- no	60	75.00%
	- yes	20	25.00%

Patients were also categorized based on reason for CCU admission. The majority of the patients being 48.75% (n=39) were admitted for emergency surgery. Patients admitted for medical reasons were 24% (n=30). Minority of patients were admitted for elective surgery and they accounted for 21.25% (n=17) of the sample.

Illness severity as determined by APACHE II score ranged from 12-40. The majority of patients had an APACHE II score between 20-25 accounting for 48.72% (n=38) of the sample. In this study, 28.21% (n=22) of the sample had an APACHE II score of 26-30 whereas 14.1% (n=4) had an APACHE II score of between 31-35 and finally 3.85% (n=3) being the minority of the sample had an APACHE II score of 36-40. In addition, a quarter of the patients, 25% (n=20) had co-morbidities, while majority of the patients, 75% (n=60) had no co-morbidities. Findings are summarized in **table 4.1**

Timing of data collection process

The data for invasive and non invasive blood pressure was collected from patients at different times as follows: Data from 8.75% (n=7) being the minority of the sample were collected between 0 and 12 hours of insertion of the arterial line. Between 12 to 24 hours data from 26.25% (n=21) were collected. Between 24 to 36hours after the insertion of the line, data from 36.25% (n=29) of the sample were collected. Between 36 to 48 hours of the insertion of the line, data from 28.75% (n=23) were collected. Findings are summarized in **figure 4.3**

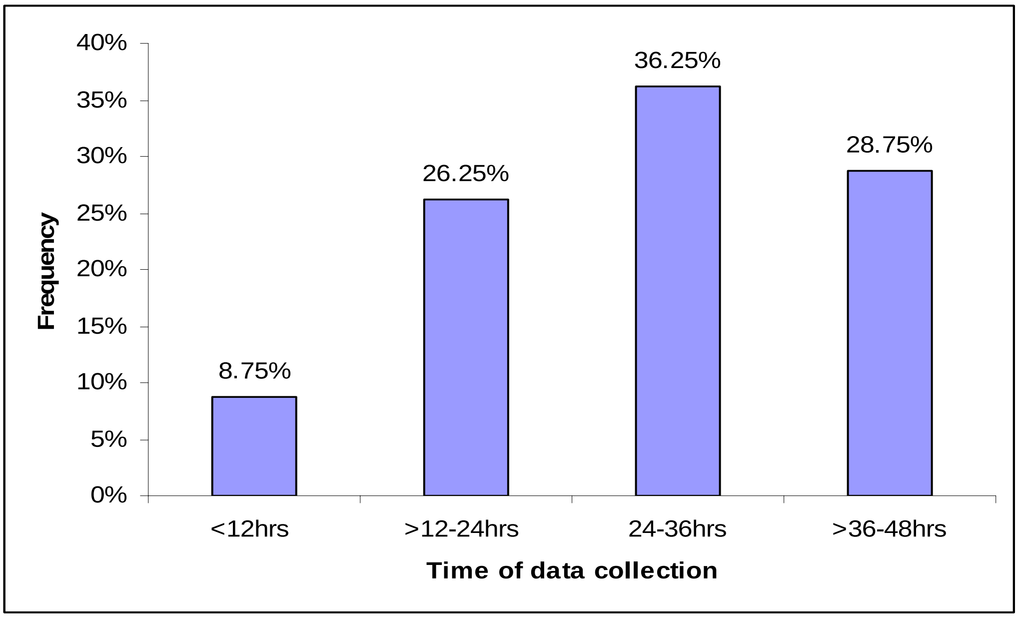

Figure 4.3: Timing of data collection process (patients)

4.3.2 Section Two: Baseline Assessment Information

Table 4.2: Summary of participant baseline information (n=80)

Item	Variable	Mean	Minimum	Maximum
2.1	Heart Rate (b/min)	106	67	132
2.2	Temperature (°C)	37.4	36.5	39.2
2.3	Invasive blood pressure (mmHg)			
	- systolic blood pressure	120.7	81.0	186.0
	- diastolic blood pressure	68.8	48.0	111.0
	- mean blood pressure	78.9	55.0	120.0
2.4	Non- invasive blood pressure (mmHg)			
	- systolic blood pressure	118.5	80.0	186.0
	- diastolic blood pressure	68.3	45.0	109.0
	- mean blood pressure	77.9	56.0	117.0
2.5	Ventilation parameters (cmH20)			
	- peak inspiratory pressure	30.0	29.0	40.0
	- pause inspiratory pressure	12.0	9.0	20.0
	- PEEP level	7.0	5.0	12.0

Heart rate: Before any blood pressure data collection, patients' heart rate was recorded as baseline on all 80 patients, the maximum heart rate was132 b/min, with a minimum of 67 b/min whereas the mean heart rate was106 b/min. **Findings are summarized in table 4.2**

Temperature: The baseline temperature was recorded for all 80 patients**.** The maximum temperature was 39.2 ^{o} C; the minimum temperature was 36.5 ^{o} C while the mean of all was 37.4 ^{o} C. **Findings are summarized in table 4.2**

Invasive blood pressure measurement: The maximum invasive SBP (Systolic blood pressure) was 186 mmHg, with a minimum of 81 mmHg, and the mean of all 80 patients was 120.7 mmHg. The maximum invasive DBP (Diastolic blood pressure) was111 mmHg, with a minimum of 45 mmHg, and the mean of all 80 patients was 68.3 mmHg. The maximum MAP (Mean arterial pressure) was111 mmHg, the minimum was 45 mmHg, and the mean of all 80 patients was 78.8 mmHg. **Findings are summarized in table 4.2**

Non-Invasive blood pressure: The maximum non-invasive SBP was 186 mmHg, the minimum was 80 mmHg, and the mean of all 80 patients was 118.5 mmHg. Maximum non-invasive DBP was109 mmHg, the minimum was 45 mmHg and the mean of all 80 patients was 68.3 mmHg. Maximum non-invasive MAP was117 mmHg, the minimum was 56.0 mmHg, the mean MAP of all patients (n=80) was 77.9 mmHg. **Findings are summarized in table 4.2**

Peak inspiratory pressure: In this study, there were 65 patients who were mechanically ventilated (n=65) and their maximum peak inspiratory pressure ranged from 40 to 29 cm/H_2o while the mean of all 65 patients was 30 cm / H_2o. **Findings are summarized in table 4.2**

Pause inspiratory pressure: Among 65 patients who were mechanically ventilated, the maximum pause inspiratory pressure was 20 cm / H_2o with a minimum of 9 cm / H_2o while the mean of all 65 patients was 12 cm / H_2o. **Findings are summarized in table 4.2**

Positive end-expiratory Pressure: 65 patients who were mechanically ventilated, the maximum PEEP was 12 cm / H_2o. The minimum was 5 cm / H_2o while the mean of all 65 patients was 7 cm / H_2o. **Findings are displayed in table 4.2**

Table 4.3: Summary of the clinical factors that influence the blood pressure measurements (n=80)

Item	Variable	F (%)	Type	Dosage
2.5	Mode of ventilation - PC - SIMV / PS - SIMV - PS, CPAP - Not ventilated	 0 (0.0%) 11(13.75%) 37(46.25%) 7 (8.75%) 15(18.75%)	Face mask	40-60% oxygen
2.9	Analgesia - yes - no	 37(46.25%) 43(53.75%)	 Morphine (iv) Tramal (iv) Panado syrup (PNGT) -	 1-2mg prn 50-100mg 6hrly 0.5 – 1g prn -
2.10	Sedation - yes - no	 37(46.25%) 43(53.75%)	 Dormicum (iv) Seranace (iv)	 1-2mg prn 5mg prn -
2.12	Inotropic / Vasopressor support - yes - no	 44(55.0%) 36(45.0%)	 Adrenalin (iv) Phenylephrine (iv) Dobutrex (iv) Nitroglycerine (TNT) -	 0.02-0.09 µg 0.3-0.7 µg 2.5-10 µg 0.2-1 µg -

Mode of ventilation: In total, 81.25% (n=65) of the patients were on mechanical ventilation with positive end-expiratory pressure (PEEP) while 18.75% (n=15) were on face mask with the oxygenation that ranged from 40-60 %. Patients were on different modes of ventilation as follows: There were no patients on Pressure Control (PC) mode, 13.75% (n=11) of the sample were on Synchronized Intermittent Mandatory Ventilation with pressure support (SIMV/PS) and 46.25% (n=37) were on SIMV mode only. Those on continuous positive airway pressure (CPAP) mode accounted only for only 8.75% (n=7) of the sample. **Findings are displayed in table 4.3**

Sedation and analgesia: In this study, 46.25% (n=37) of the sample were on sedation such as Dormicum intravenous (IV) 1-2mg as necessary (PRN), Serenace intravenous 5mg as necessary (PRN) and analgesia such as morphine intravenous 1-2mg as necessary, Tramal intravenous 50-100mg six hourly and Panado syrup per naso-gastric tube 0.5g-1g PRN. The rest 53.75% (n=43) were not on any analgesia or sedation. **Findings are displayed in table 4.3**

Inotropic and vasopressor support: 55% (n=44) of the sample were on inotropic and / or vasopressor support such as Adrenalin 0.02-0.09 microgram (μg), Phenylephrine 0.3-0.7 μg, Dobutrex 2.5-10 μg and Nitro-glycerine (TNT) 0.2-1 μg while 45%(n=36) were not on any inotropic or vasopressor support. **Findings are displayed in table 4.3**

4.3.3 Section three: Level of agreement between blood pressure measurements

4.3.3.1 Difference between systolic NIBP and systolic IBP

In this section the test of the difference, strength of the relationship (correlation) together with the limits of agreement between invasive and non invasive BP will be measured in three sections of systolic BP, diastolic BP and mean BP for all 80 subjects, and according to their time of collection.

All 80 subjects were tested to see if there were significant difference between invasive and non invasive systolic BP measurement methods and 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 IBP and NIBP measurements methods were significantly different. The IBP was 2.15 mmHg higher than average compared to NIBP systolic blood pressure method. Findings are displayed in **Figure 4.4**.

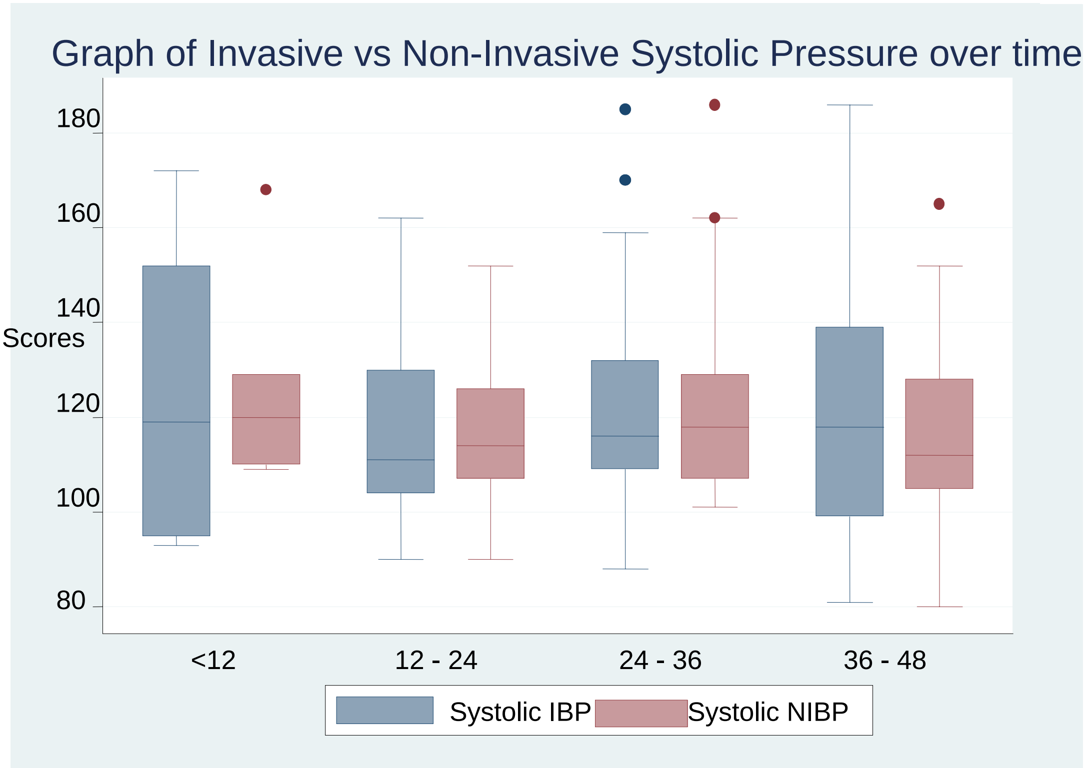

Figure 4.4: Difference between invasive and non invasive systolic blood pressure

4.3.3.2 Relationship between systolic NIBP and systolic IBP

A correlation of (r) =0.302 (p<0.001) was found as shown in scatter plot on **Figure 4.5** below with a very small probability. It was concluded that invasive and non invasive BP measurement methods were not related; however this does not mean that these two methods agree.

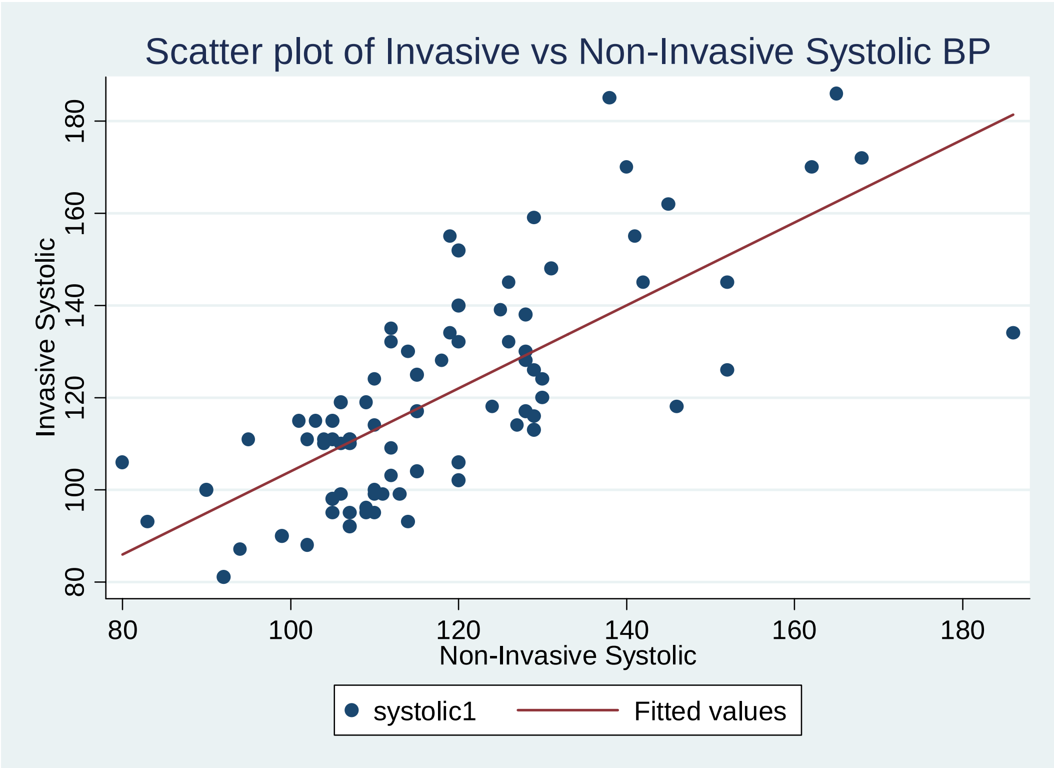

Figure 4.5: Relationship between systolic NIBP and systolic IBP

4.3.3.3 Agreement between systolic NIBP and systolic IBP

The limits of agreement was determined by calculating the bias estimated by the mean difference (d), the standard deviation of the differences in means(S) and by subtracting the consistent bias from invasive BP measurements. For normally distributed data, 95% of the differences are expected to lie between (d-2S) and (d+2S). Agreement of invasive and non invasive systolic BP measurement methods were undertaken in order to show how much the invasive and non invasive BP agrees. A plot of the difference against the mean allows one to investigate any possible relationship between measurement error and the true value. There were 80 measurements of IBP and NIBP systolic. Mean difference (bias) $\bar{d}$ was 2.15 and this meant that the IBP systolic tends to give higher readings compared to NIBP systolic by 2.15mmHg. At 95% confidence interval, the range of IBP systolic under estimation of NIBP systolic was from 1.468 to 5.786.

This means that the IBP systolic tend to give a lower reading of systolic non invasive within the range of -1.468 and 5.786, the standard deviation (SD) of the difference in means of IBP and NIBP systolic was found to be 16.25. The limit of agreement was calculated by using the formula (d−2SD) and (d+2SD) i.e. 2.15−2 (16.25) = -30.362 and 2.15+2(16.25) =34.662.

The limits of agreement were found to be between -30.362 and +34.662 **(figure 4.6)**. This means that the IBP systolic tends to underestimate the NIBP systolic reading by as much as 30.36mmHg and overestimate the NIBP systolic by up to 30.37 mmHg.

The p-value was 0.007 which was lower than 0.05 level of significance; the p-value level of significance meant that IBP systolic readings were significantly different, lower than NIBP systolic measurements.

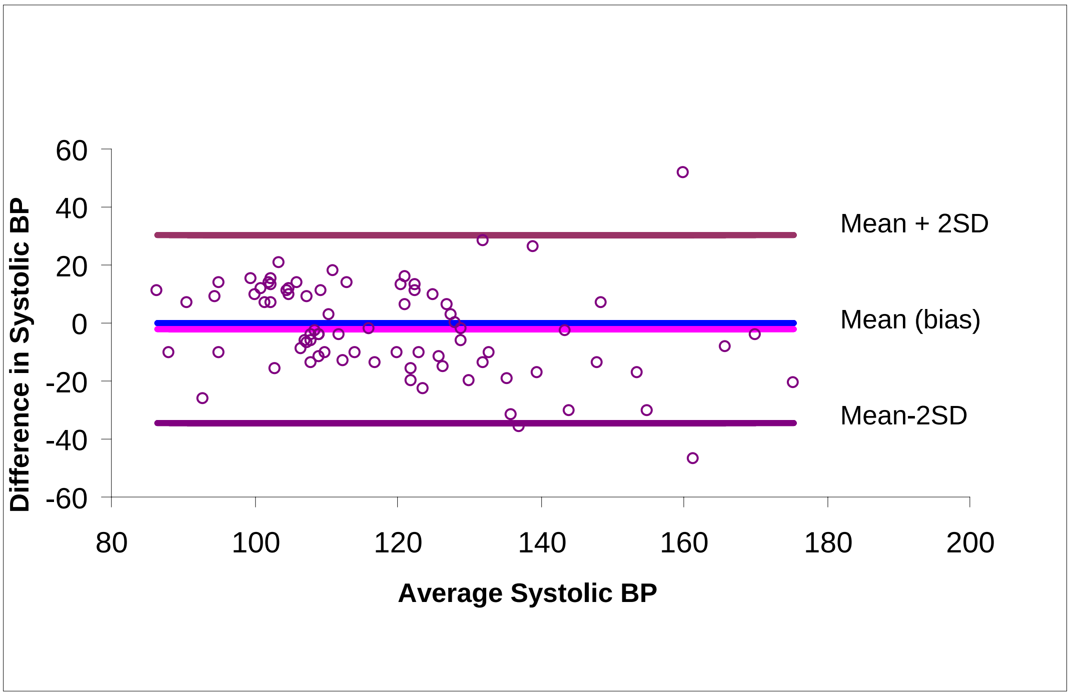

Figure 4.6: Agreement between systolic NIBP and systolic IBP

4.3.3.4 Difference between invasive and non invasive diastolic BP

Statistical differences between IBP and NIBP diastolic measurement methods were tested and it was found that there was no significant differences between the two methods on average (p=0.239> 0.05) the level of significance meant that IBP and NIBP measurement methods were not significantly different. The IBP was 2.143 mmHg lower than on average compared to NIBP diastolic method but not significantly different.

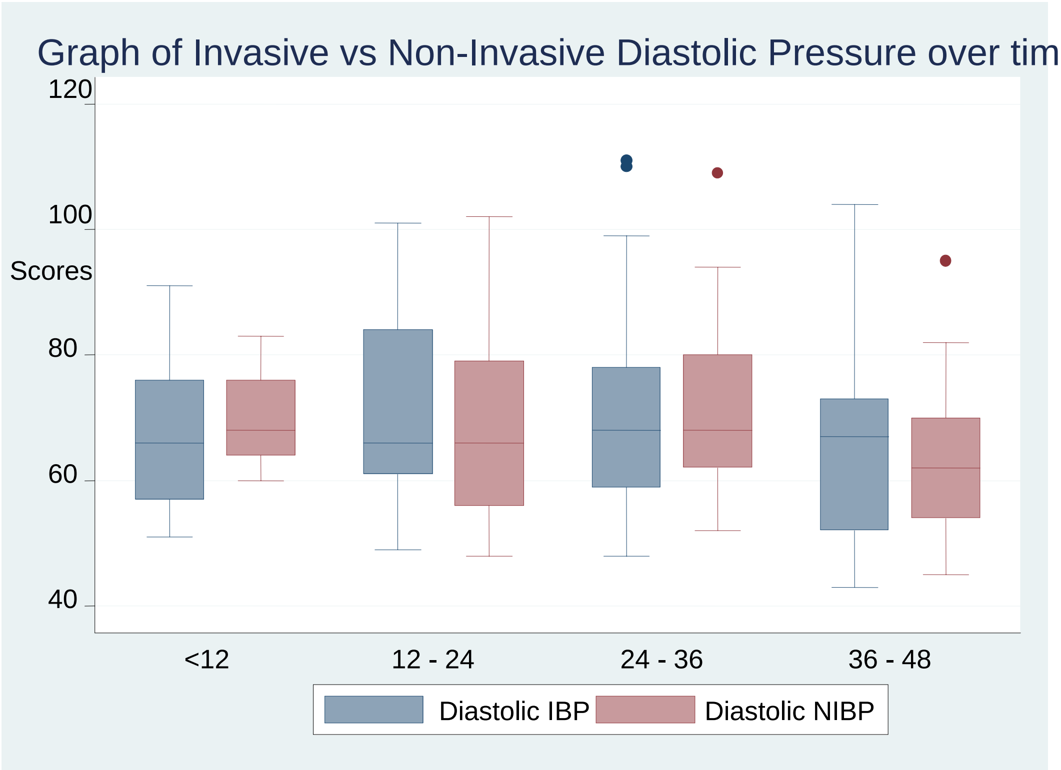

Figure 4.7: Difference between IBP and NIBP diastolic

4.3.3.5 Relationship between invasive and non-invasive Diastolic BP

In **figure 4.8**, Correlation(r) = 0.513 ($p<0.001$) the probability is very small so it can be concluded that IBP and NIBP diastolic are related, however this correlation does not mean that these two methods agree.

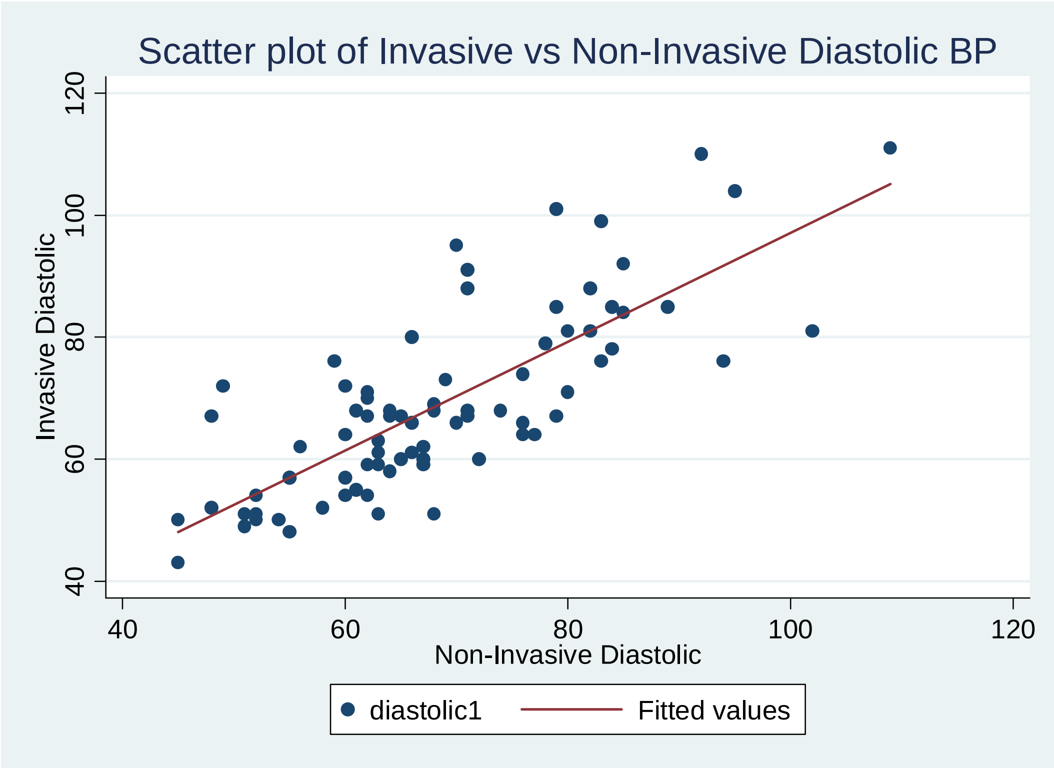

Figure 4.8: Relationship between IBP and NIBP Diastolic measurement

4.3.3.6 Agreement between diastolic NIBP and diastolic IBP

All 80 subjects in **figure 4.9** were plotted to measure the limits of agreement between IBP diastolic and NIBP diastolic. 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. The p-value 0.062 greater than 0.05 meant that there was no significant difference between the IBP diastolic and NIBP diastolic measurements with the confidence interval being -1.62 to 2.60.

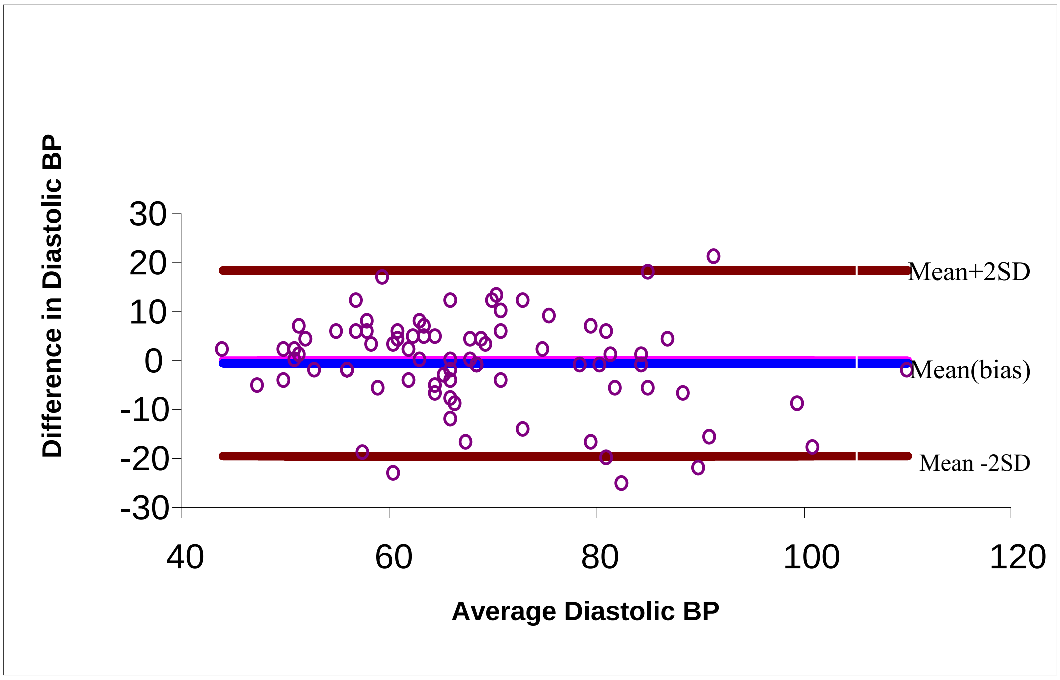

Figure 4.9: Agreement between diastolic NIBP and diastolic IBP

4.3.3.7 Difference between invasive and non invasive mean BP

The test to see if there was significant difference between two methods of invasive mean BP and non invasive mean BP was done and it was found that there was no significant difference between the two blood pressure methods. On average, the p-value was 0.443 >0.05 level of significance meaning that invasive mean BP and non invasive mean BP measurement methods were not significantly different. The invasive mean BP was 1.013 higher compared to non invasive mean BP method but not significantly different.

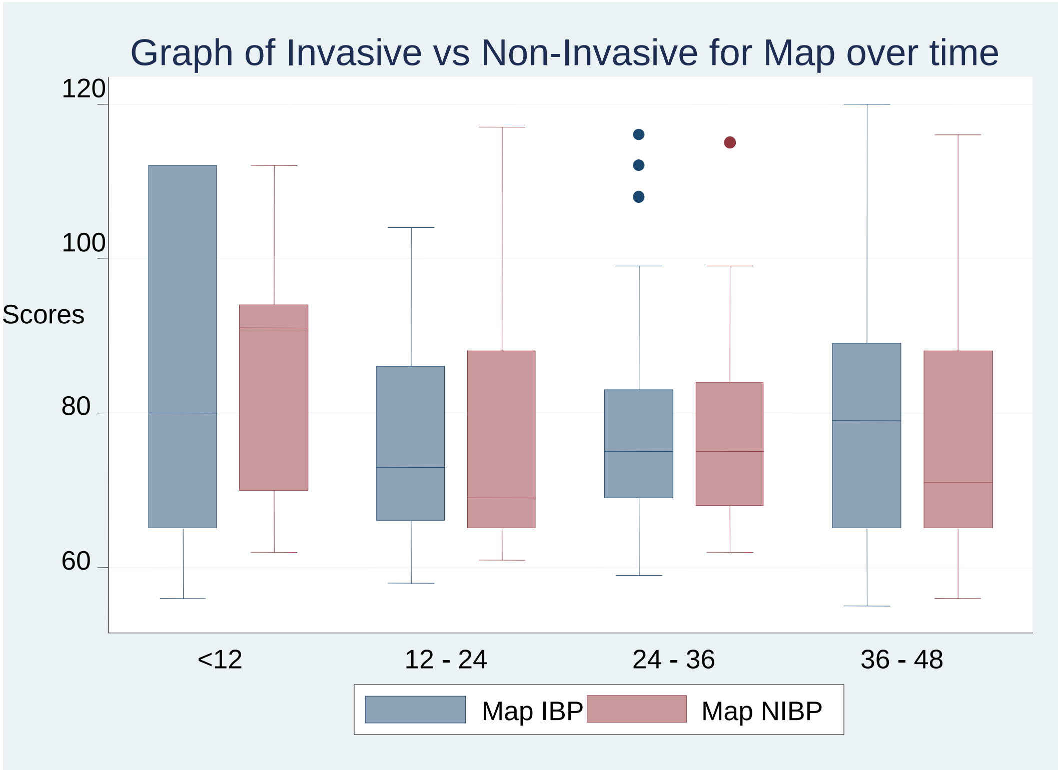

Figure 4.10: Differences between IBP MAP and NIBP MAP

4.3.3.8 Relationship between IBP and NIBP MAP measurements

Correlation(r) = 0.087($p<0.001$) the probability is very small and it can be concluded that NIBP and NIBP MAP 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.

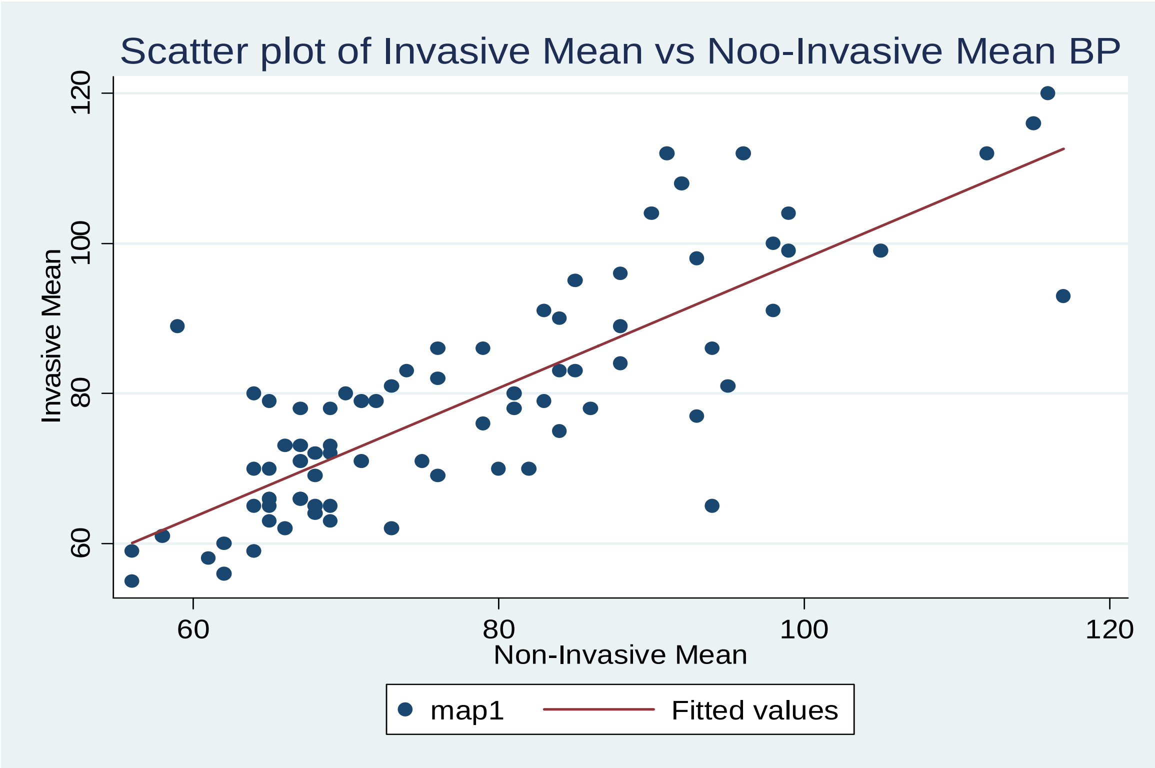

Figure 4.11: Differences between IBP MAP and NIBP MAP

4.3.3.9 Agreement between invasive and non-invasive MAP measurements

The limits of agreement between IBP and NIBP MAP were calculated in order to show how much the IBP and NIBP MAP agrees.

Plot of the difference against the mean allows one to investigate any possible relationship between the measurement error and the true value, the mean of the two measurements is the best estimate available, because the true value is not known. There were 80 measurements of IBP and NIBP MAP, Mean difference (bias d¯) was 1.01. This meant that the IBP MAP tends to give higher readings compared to NIBP MAP by 1.01mmHg. At the 95% confidence of interval, the range of IBP MAP, the underestimation of non invasive mean BP was from -1.01 to 3.04. This meant that the invasive mean BP tended to give the lower reading of non invasive mean within the range -1.01 and 3.04, the standard (SD) of the difference in means invasive mean and non invasive mean BP was found to be 9.12.

The limits of agreement was calculated by using the formula (d-2SD) and (d+2SD) I.e. 1.01-2(9.12) =-17.23 and 1.01+2(9.12) =19.25. The limits of agreement was found to be -17.23 and 19.25 (**Figure 4.12**) this means that invasive mean BP tend to underestimate the non invasive mean BP reading by as much as 17.23 and overestimate non invasive mean BP by up to 19.25.

The p-value was 0.443 which was greater than the 0.05 level of significance; it shows that invasive mean BP and non invasive mean BP measurement were not significantly different

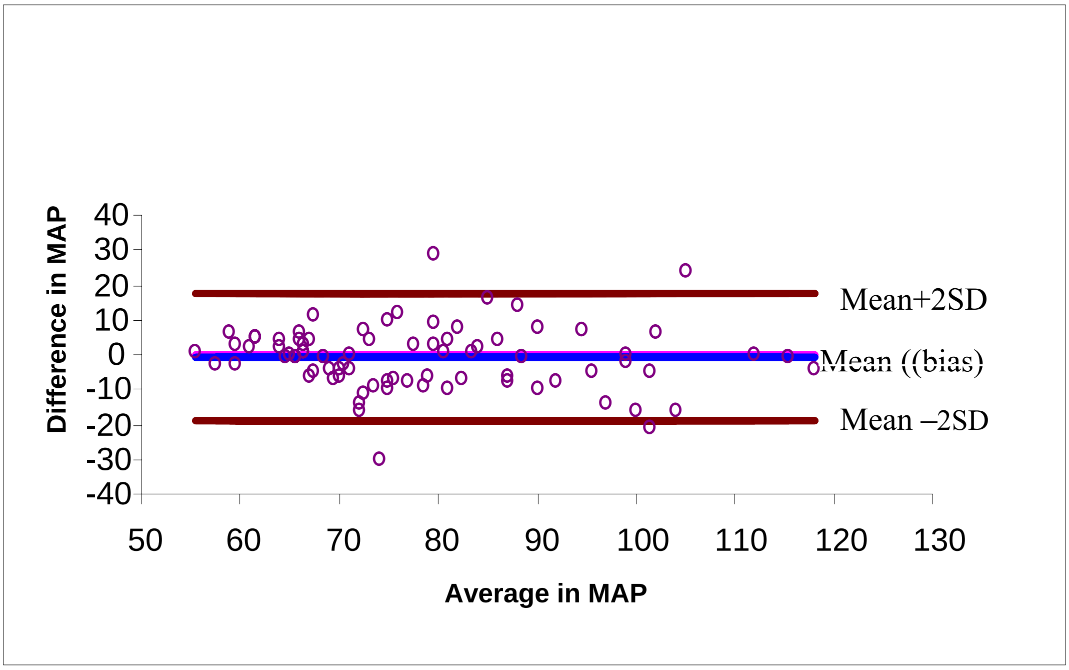

Figure 4.12: Agreement between NIBP MAP and IBP MAP

The limits of agreement for NIBP and IBP systolic at the different times could be summarized as follows: With the average limits of agreement of systolic being between +34.05 and -30.89 over the range of time of 0-12h, 12-24h, 24-36h, 36-48h. IBP systolic could be underestimated by -30.89 and overestimated by 34.05. The mean bias was 1.60 with the NIBP systolic tending to underestimate the IBP systolic readings by 1.60. The p value was 0.15 greater than 0.05 level of significance, meaning that IBP systolic and NIBP systolic were not significantly different. **(Refer to table 4.4).**

The limits of agreement IBP and NIBP diastolic at the different times could be summarized as follows: With the average limits of agreement of diastolic being between +20.13 and -19.92 over the range of time of 0-12h, 12-24h, 24-36h, 36-48h. IBP diastolic could be underestimated by 19.92 and overestimated by 20.13. The mean bias was 0.10 with the NIBP diastolic tending to underestimate the IBP diastolic readings by 0.10. The p value was 0.33 greater than 0.05 of the level of significance, meaning that IBP diastolic and NIBP diastolic were not significantly different. **(Refer to table 4.4).**

The limits of agreement for NIBP and IBP MAP at the different times could be summarized as follows: With the average limits of agreement of map being between +20.69 and -20.11 over the range of time of 0-12h, 12-24h, 24-36h, 36-48h. IBP map could be underestimated by 20.11 and overestimated by 20.69. The mean bias was 1.14 with the NIBP map tending to underestimate the IBP map readings by 1.14. The p value was 0.31 greater than 0.05 level of significance, meaning that IBP map and NIBP map were not significantly different**. (Refer to table 4.4).**

Table 4.4 Summary of agreement and bias between NIBP and IBP (systolic, diastolic and MAP) at different times of data collection

Type of BP measurement	Timing	NIBP underestimation of IBP (mmHg)	NIBP overestimation of IBP (mmHg)	Mean Difference (Bias)	SD	P-Value
NIBP and IBP systolic	<12 hrs	37.17	35.46	-0.85	18.6	0.26
	12-24 hrs	21.46	23.1	0.85	11.15	0.21
	24-36 hrs	35.98	40.05	2.03	19.01	0.07
	36 – 48 hrs	28.83	37.62	4.39	16.61	0.07
	Mean	**-30.89**	**34.05**	**1.60**	**16.34**	**0.15**
NIBP and IBP diastolic	<12 hrs	26.29	22.00	-2.14	12.07	0.24.
	12-24 hrs	20.09	20.57	0.23	10.10	0.93
	24-36 hrs	17.96	16.44	-0.75	8.60	0.05
	36 – 48 hrs	15.35	21.52	3.08	9.21	0.11
	Mean	**19.92**	**20.13**	**0.10**	**9.99**	**0.33**
NIBP and IBP mean	<12 hrs	35.78	29.78	-3.00	16.39	0.47
	12-24 hrs	18.75	17.61	-0.57	9.09	0.16
	24-36 hrs	14.91	16.77	0.93	7.92	0.06
	36 – 48 hrs	11.03	18.60	3.78	7.48	0.55
	Mean	**20.11**	**20.69**	**1.14**	**10.22**	**0.31**

Table 4.5: Summary of limits of agreement between IBP and NIBP based on factors that influence the two BP measuring techniques

Factors affecting BP	**Category of BP**	**NIBP underestimation of IBP (mmHg)**	**NIBP overestimation of IBP (mmHg)**	**Mean difference (Bias)**	**P-value**
Inotropic support	Systolic	33.79	34.34	0.27	0.001
	Diastolic	20.56	17.84	-1.36	0.049
	MAP	17.83	17.00	-0.41	0.026
	Mean	**24.06**	**23.06**	**-0.5**	**0.02**
No inotropic support	Systolic	27.55	34.92	3.68	0.82
	Diastolic	16.51	20.51	2.00	0.99
	MAP	16.58	20.4	2.18	0.13
	Mean	**20.21**	**25.27**	**2.62**	**0.64**
Sedation / analgesia	Systolic	36.27	34.27	-0.93	0.034
	Diastolic	18.00	15.95	-1.02	0.042
	MAP	20.39	18.39	-1.00	0.26
	Mean	**24.79**	**22.87**	**-0.98**	**0.11**
No sedation / analgesia	Systolic	21.93	33.37	5.73	0.10
	Diastolic	18.56	23.04	2.24	0.65
	MAP	12.45	19.15	3.35	0.658
	Mean	**17.6**	**25.18**	**3.77**	**0.46**

Table 4.6: Summary of limits of agreement between IBP and NIBP based on factors that influence the two BP measuring techniques

Factors affecting BP	Category of BP	NIBP underestimation of IBP (mmHg)	NIBP overestimation of IBP (mmHg)	Mean difference (Bias)	P-value
Mechanical ventilation with PEEP	Systolic	31.50	32.95	0.72	0,046
	Diastolic	18.53	19.14	0.30	0.025
	MAP	12.27	30.46	9.09	0.047
	Mean	**20.76**	**27.51**	**3.37**	**0.03**
No mechanical ventilation with PEEP	Systolic	23.52	40.18	8.33	0,08
	Diastolic	19.03	21.57	1.26	0.40
	MAP	23.35	25.75	1.20	0.18,
	Mean	**21.9**	**29.1**	**3.59**	**0.22**
APACHE II score above 30	Systolic	31.51	35.51	2.00	0.16
	Diastolic	20.69	20.55	-0.07	0.30
	MAP	19.92	22.92	1.50	0.85
	Mean	**24.04**	**26.32**	**1.14**	**0.43**
APACHE II Score below 30	Systolic	30.53	35.25	2.35	0.017
	Diastolic	18.43	19.74	0.65	0.11
	MAP	17.03	18.72	0.84	0.051
	Mean	**21.99**	**24.57**	**1.28**	**0.06**

The limits of agreement of IBP and NIBP for patients who were **on inotropic** support could be summarized as follows: With the average limits of agreement of systolic, diastolic, and mean being between -24.06 and +23.06. IBP could be underestimated by 24.06 and overestimated by 23.06. The mean bias was -0.5 with the NIBP tending to underestimate the IBP readings by 0.5. The p value was 0.02 lower than 0.05 of the level of significance, Meaning that IBP and NIBP on inotropic and vasopressor support were significantly different**. (Refer to table 4.5)**

The limits of agreement of IBP and NIBP for patients who were **not on any form of inotropic** support could be summarized as follows: With the average limits of agreement of systolic, diastolic, and mean being between -20.21 and +25.27. IBP could be underestimated by 20.21 and overestimated by 25.27. The mean bias was 2.62 with the NIBP tending to overestimate the IBP readings by 2.62. The p value was 0.64 greater than 0.05 of the level of significance, Meaning that IBP and NIBP with no inotropic and vasopressor support were not significantly different. **(Refer to table 4.5)**

The limits of agreement of IBP and NIBP for patients who were **on sedation/ analgesics** could be summarized as follows: With the average limits of agreement of systolic, diastolic, and mean being between -24.79 and +22.87. IBP could be underestimated by 24.79 and overestimated by 22.87. The mean bias was -0.98 with the NIBP tending to underestimate the IBP readings by 0.98. The p value was 0.11 greater than 0.05 of the level of significance, Meaning that IBP and NIBP on sedation and analgesia were not significantly different. **(Refer to table 4.5)**

The limits of agreement of IBP and NIBP for patients who were **not on sedation/ analgesics** could be summarized as follows: With the average limits of agreement of systolic, diastolic, and mean being between -17.6 and +25.18. IBP could be underestimated by 17.6 and overestimated by 25.18. The mean bias was 3.77 with the NIBP tending to overestimate the IBP readings by 3.77. The p value was 0.46 greater than 0.05 of the level of significance, Meaning that IBP and NIBP not on sedation and analgesia were not significantly different. **(Refer to table 4.5)**

The limits of agreement of IBP and NIBP for patients who were **on mechanical ventilation** with PEEP could be summarized as follows: With the average limits of agreement of systolic, diastolic, and mean being between -20.76 and +27.51. IBP could be underestimated by 20.76 and overestimated by 27.51. The mean bias was 3.37 with the NIBP tending to overestimate the IBP readings by 3.37. The p value was 0.03 lower than 0.05 of the level of significance, Meaning that IBP and NIBP on mechanical ventilation were significantly different. **(Refer to table 4.6)**

The limits of agreement of IBP and NIBP for patients who were **not on mechanical ventilation** with PEEP could be summarized as follows: With the average limits of agreement of systolic, diastolic, and mean being between -21.9 and +29.1. IBP could be underestimated by 21.9 and overestimated by 29.9. The mean bias was 3.59 with the NIBP tending to overestimate the IBP readings by 3.59. The p value was 0.22 greater than 0.05 of the level of significance, meaning that IBP and NIBP not on mechanical ventilation were not significantly different. **(Refer to table 4.6)**

The limits of agreement of IBP and NIBP for patients whose **APACHE II score was above 30** could be summarized as follows: With the average limits of agreement of systolic, diastolic, and mean being between -24.04 and +26.32. IBP could be underestimated by 24.04 and overestimated by 26.32. The mean bias was 1.14 with the NIBP tending to overestimate the IBP readings by 1.14.The p value was 0.43 greater than 0.05 of the level of significance, meaning that IBP and NIBP of the **APACHE II score of above 30** were not significantly different. **(Refer to table 4.6)**

The limits of agreement of IBP and NIBP for patients whose **APACHE II score was below 30** could be summarized as follows: With the average limits of agreement of systolic, diastolic, and mean being between -21.99 and +24.57. IBP could be underestimated by 21.9 and overestimated by 29.9. The mean bias was 1.28 with the NIBP tending to overestimate the IBP readings by 1.28. The p value was 0.06 greater than 0.05 of the level of significance, Meaning that IBP and NIBP of the **APACHE II score of below 30** were not significantly different. **(Refer to table 4.6)**

Table 4.7: Summary of limits of agreement between IBP and NIBP for patients admitted to ICU for different reasons (medical, elective and emergency surgery) (n=80)

Reason for admission	Category of BP	NIBP underestimation of IBP (mmHg)	NIBP overestimation of IBP (mmHg)	Mean Difference (Bias)	SD	P-Value
Medical	Systolic	32.79	33.29	0.25	0.03	16.52
	Diastolic	23.26	18.26	-2.50	0.42	10.38
	MAP	23.3	19.38	-2.00	0.81	10.69
Elective surgery	Systolic	32.54	43.48	5.47	0.07	19.00
	Diastolic	20.62	21.44	0.41	0.51	10.51
	MAP	12.43	19.84	3.70	0.20	8.06
Emergency Surgery	Systolic	28.10	32.85	1.87	0.73	14.98
	Diastolic	13.97	18.68	2.35	0.12	8.16
	MAP	12.23	19.84	3.40	0.18	8.17

In this study, 24 patients 30% of the sample were collected from medical CCU, with the limits of agreement of systolic, being between -32.79 and +33.29. IBP could be underestimated by 32.79 and overestimated by 33.29. The mean bias was 0.25 with the NIBP tending to overestimate the IBP readings by 025. The p value was 0.03 lower than 0.05 of the level of significance, Meaning that IBP systolic and NIBP systolic were significantly different. **(Refer to table 4.7)**

In this study, 24 patients 30% of the sample were collected from medical CCU, with the limits of agreement of diastolic, being between -23.26 and +18.26. IBP diastolic could be underestimated by 23.26 and overestimated by18.26. The mean bias was -2.50 with the NIBP tending to overestimate the IBP readings by -2.50. The p value was 0.43 greater than 0.05 of the level of significance, Meaning that IBP diastolic and NIBP diastolic were not significantly different in medical CCU. **(Refer to table 4.7)**

In this study, 24 patients 30% of the sample were collected from medical CCU, with the limits of agreement of MAP, being between -23.3 and +19.38. IBP MAP could be underestimated by 23.3 and overestimated by19.38. The mean bias was -2.00 with the NIBP MAP tending to underestimate the IBP MAP readings by -2.00. The p value was 0.81 greater than 0.05 of the level of significance, Meaning that IBP MAP and NIBP MAP were not significantly different. **(Refer to table 4.7)**

In this study, 17 patients 21.25% of the sample were collected from elective surgery CCU, with the limits of agreement of systolic, being between -32.54 and +43.48. IBP systolic could be underestimated by 32.54 and overestimated by 43.48. The mean bias was 5.47 with the NIBP systolic tending to overestimate the IBP systolic readings by 5.47 the p value was 0.07 greater than 0.05 of the level of significance, Meaning that IBP systolic and NIBP systolic were not significantly different. **(Refer to table 4.7).**

In this study, 17 patients 21.25% of the sample were collected from elective surgery CCU, with the limits of agreement of diastolic, being between -20.62 and +21.44. IBP diastolic could be underestimated by 20.62 and overestimated by 21.44. The mean bias was 0.41 with the NIBP diastolic tending to overestimate the IBP diastolic readings by 0.41 the p value was 0.51 greater than 0.05 of the level of significance, Meaning that IBP diastolic and NIBP diastolic were not significantly different. **(Refer to table 4.7).**

In this study, 17 patients 21.25% of the sample were collected from elective surgery CCU, with the limits of agreement of MAP, being between -12.43 and +19.84. IBP MAP could be underestimated by 12.43 and overestimated by 19.84. The mean bias was 3.70 with the NIBP MAP tending to overestimate the IBP MAP readings by 3.70 The p value was 0.20 greater than 0.05 of the level of significance, Meaning that IBP MAP and NIBP MAP were not significantly different. **(Refer to table 4.7).**

In this study, 39 patients 48.75% of the sample were collected from emergency surgery CCU, with the limits of agreement of systolic, being between -28.10 and +32.85. IBP systolic could be underestimated by 28.10 and overestimated by 32.85. The mean bias was 1.87 with the NIBP systolic tending to overestimate the IBP systolic readings by 1.87 the p value was 0.73 greater than 0.05 of the level of significance, Meaning that IBP systolic and NIBP systolic were not significantly different in emergency surgery CCU. **(Refer to table 4.7).**

In this study, 39 patients 48.75% of the sample were collected from emergency surgery CCU, with the limits of agreement of diastolic, being between -13.97 and +18.68. IBP diastolic could be underestimated by 13.97 and overestimated by 18.68. The mean bias was 2.35 with the NIBP diastolic tending to overestimate the IBP diastolic readings by 2.35 the p value was 0.12 greater than 0.05 of the level of significance, Meaning that IBP diastolic and NIBP diastolic were not significantly different in emergency surgery CCU.

In this study, 39 patients 48.75% of the sample were collected from emergency surgery CCU, with the limits of agreement of MAP, being between -12.23 and +19.84. IBP MAP could be underestimated by 12.23 and overestimated by 19.84. The mean bias was 3.40 with the NIBP MAP tending to overestimate the IBP MAP readings by 3.40 The p value was 0.18 greater than 0.05 of the level of significance, Meaning that IBP MAP and NIBP MAP were not significantly different in emergency surgery CCU. **(Refer to table 4.7).**

Table 4.8: Comparison of the limits of agreement and bias between IBP and NIBP systolic, diastolic and MAP

Type of BP measurement	Timing	Category of BP	NIBP underestimation of IBP (mmHg)	NIBP overestimation of IBP (mmHg)	Mean Difference (Bias)	SD	P-value
IBP and NIBP Systolic	< 12 hrs	Systolic	37.17	35.46	-0.85	18.16	0.25
	12-24 hrs	Systolic	21.46	23.1	0.85	11.15	0.21
	24-36 hrs	Systolic	35.98	40.05	2.03	19.01	0.07
	36-48 hrs	Systolic	28.83	37.62	4.39	16.61	0.29
	Mean		**30.89**	**34.05**	**1.60**	**16.23**	**0.20**
IBP and NIBP diastolic	< 12 hrs	Diastolic	26.29	22.00	-2.14	12.07	0.23
	12-24 hrs	Diastolic	20.09	20.57	0.23	10.10	0.92
	24-36 hrs	Diastolic	17.96	16.44	-0.75	8.60	0.05
	36-48 hrs	Diastolic	15.35	21.52	3.08	9.21	0.10
	Mean		**19.92**	**20.13**	**0.10**	**9.99**	**0.32**
IBP and NIBP MAP	< 12 hrs	MAP	35.78	29.78	-3.00	16.39	0.47
	12-24 hrs	MAP	18.75	17.61	-0.57	9.09	0.16
	24-36 hrs	MAP	14.91	16.77	0.93	7.92	0.06
	36-48 hrs	MAP	11.03	18.60	3.78	7.40	0.54
	Mean		**20.11**	**20.69**	**1.14**	**10.2**	**0.30**

4.3.4 Section Four: Comparison of the limits of agreement between invasive and noninvasive BP as to what is clinically aceptable in critical care unit

The comparison of limits of agreement of systolic blood pressure are wide reflecting the great variation of the differences and poor agreement of the mean of systolic underestimation of -30.89 mmHg and the mean of systolic overestimation of +34.05 mmHg, while the mean of the mean difference (bias) is 1.60. **(Refer to table 4.8).**

The comparison of limits of agreement of diastolic blood pressure are wide reflecting the great variation of the differences and poor agreement of the mean of diastolic underestimation of -19.92 mmHg and the mean of systolic overestimation of +20.13 mmHg, while the mean of the mean difference (bias) is 0.10 .As shown on the **table 4.8**.

The comparison of limits of agreement of mean arterial blood pressure are wide reflecting the great variation of the differences and poor agreement of the mean of MAP underestimation of -20.11 mmHg and the mean of MAP overestimation of +20.69 mmHg, while the mean of the mean difference (bias) is 1.14 As shown by the summary in **table 4.8**.

Part two of the study in assessment of the limits of agreement between invasive and non invasive blood pressure

4.3.5 Section Five: Opinion of CCU staff on IBP and NIBP blood pressure measurements.

Table 4.9: Demographic data of clinical practitioners (n=50)

Item	Demographic data	F (%)	Mean (Yrs)	Range (Yrs)
	Professional status			
	- Doctor	6(12.0%)	-	-
	- Nurse	44(88.0%)	-	-
	Academic qualification			
	- Doctors	6(12.0%)	-	-
	- BSc Nursing	14(28.0%)	-	-
	- Diploma in general nursing	30(60.0%)	-	-
	Years worked in CCU			
	- Doctors	-	7.3	5-10
	- BSc nursing	-	3.9	2-5
	- Diploma in general nursing	-	4.9	2-10

In total, 50 clinical practitioners including doctors and nurses participated in this study. There were 12% (n=6) medical doctors working in CCU and they had between 5 to 10 years of CCU experience with mean years of experience being 7.3 years. **(Refer to table 4.9).**

In total, there were 88% (n=44) nurses. 28% (n=14) had a Bachelor of Science degree (BSc degree in nursing) with 2 to 5 years of CCU experience and mean years of experience being 3.9. **(Refer to table 4.9).**

In this study, 60% (n=30) of the nurses had a diploma in general nursing with their years of experience ranging from 2 to 10 and average of 4.9 years. **(Refer to table 4.9).**

Opinions of clinical practitioners

In this study, 80% (n=40) of the clinical practitioners responded that the IBP was more accurate than NIBP in critically ill patients while 20% (n=10) clinical practitioners of the sample chose the NIBP over IBP.

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 the most accurate method of blood pressure measurement (Clark, et al., 2002) Some respondents also said that they trust NIBP as it can give a quick reflection of hemodynamic status that can prompt a clinical practitioner to take relevant and suitable action without unnecessary delay. They all insisted that proper calibration, leveling and zeroing and other precautionary measures before declaring it accurate and reliable.

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 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 pressure as you do not need to do anything when recording the blood pressure. The minority of clinical practitioners being 8% (n=4) specifically medical doctors working in CCU did not agree with CCU nurses that IBP is the easiest method of measuring the blood pressure as it takes energy, concentration and time to insert the arterial lines. They consider IBP as accurate but definitely not easy.

4.4 DISCUSSION OF FINDINGS

Accurate measurement of blood pressure is essential for rational hemodynamic management of critically ill patients, because of so much confusion in blood pressure monitoring it is still unclear whether IBP and NIBP measurements could be used interchangeably, available literature suggest that a wide discrepancy exists between blood pressure monitoring methods, supporting the use of IBP in monitoring and to guide treatment decision because of their accuracy (Araghi, et al., 2006).

The purpose of the study was to describe and compare the limits of agreement between IBP and NIBP reading obtained in adult critical care units of a tertiary health care institution, to determine the factors that affect accuracy of both techniques in the critical care unit as well as to describe the reasons given by the clinical practitioner for their choice of blood pressure monitoring technique in critical care units, in order to find out weather one method of measuring the blood pressure should be relied up on or both methods should be used interchangeably.

A sample of eighty (n=80) patients between the age of 18 years to 50 years old, with the radial arterial line not older than 48 hours of insertion, were collected in five different CCUs, 30% (n=24) patients in medical CCU, 21.25% (n=17) in cardiothoracic and coronary care CCU as elective surgery and 48.75% (n= 39) in trauma and neuro-surgical CCU as emergency surgery. Patient's severity of illness as determined by the APACHE II score ranged from 12-40.

Eighty one point twenty five per cent (n=65) were mechanical ventilated and 18.75% (n=15) were not mechanical ventilated. Forty six point twenty five per cent (n=37) were on sedation /analgesia, while 53.75% (n=43) were not on sedation /analgesia. 55% (n=44) patients were on inotropic/vasopressor support while 45% (n=36) were not on inotropic/ vasopressor support.

Limits of agreement

The limits of agreement were useful in determining whether one method of BP can be relied upon or if both can be used interchangeably. Apart from establishing the limits of agreement for all IBP and NIBP (systolic, diastolic and mean arterial pressure) measurements the limits of agreements are also discussed with regard to factors that influence or affect the relationship between IBP and NIBP, namely level of severity of illness APACHE II score, mechanical ventilation, sedation / analgesia, and use of inotropic / vasopressor support.

The data collected were plotted according to designated time intervals as follows: 0-12hrs, data collected was seven patients (n=7) , from 12hrs-24hrs, data collected was twenty one patients(n=21), from 24hrs-36hrs, data collected was twenty nine patients (n=29) , from 36hrs -48hrs, data collected was twenty three (n=23).

The plots and limits of agreement determined at 95%confidence interval were done and calculated for IBP and NIBP systolic, diastolic and MAP. Paired T-test was used to determine the significance of the differences between the means of the two BP sets with the level of significance set at $p \leq 0.05$.

Bland and Altman (2003); Bland and Altman (1986) suggested that before calculation of limits of agreement, it is useful to decide what constitutes a clinical important difference in accordance with your experience or according to other number of studies. In this study of assessing the limits of agreement between IBP and NIBP the need was to know what is the acceptable limit for clinicians or researchers who rely on that clinical blood pressure measurement to make appropriate decision in critical times (Byra-Cook, Dracup & Lazik,1990). Bruya and Demand (1985) reported that critical care nurses judge a difference of 10mm hg between IBP and NIBP to be acceptable even though differences of 30 mmHg may be considered normal in patients who have had cardiovascular surgery particularly in the immediate postoperative period, in this study 21.25% of the sample were elective surgery with different cardiovascular and cardiothoracic surgery. (Bruya & Demand, 1985). Clearly the decision of acceptable difference is one of judgment, which will vary depending on the circumstance. Bruya, et al (1985); Pytte, et al (2006), Bur Herkener, et al (2003) argue that blood pressure is an indicator influenced by personal, contextual physiologic and interpersonal parameters. In this study the 10 mmHg guideline cited by Bruya and Demand seem the most appropriate for interpreting the results of descriptive analysis generated by determining the limits of agreement between the two readings. (Campbell, 1997; Lough, 1987)

On average the limits of agreement for systolic blood pressure in all five critical care units, in different hours <12,12-24,24-36, 36-48 hours ranged from -30.89 to +34.05 mmHg. With the average of the paired t-test of 0.20 in relation to $p \leq 0.05$. Although a number of studies has shown than systolic blood pressure might be high compare to diastolic and mean, these limits of agreement are in agreement with what has been suggested by Bruya and Demand and other studies.

On average the limits of agreement for diastolic blood pressure in all five critical care units , in different hours, <12,12-24,24-36, 36-48 hours ranged from -19.92 to +20.13 mmHg. With the average of the paired t-test of 0.32 in relation to $p \leq 0.05$. These limits of agreement seem higher than what has been suggested by Bruya and Demand and other studies as to what is acceptable as frame of reference between IBP and NIBP (Bruya et al, 1985; Pytte, et al, 2006)

On average the limits of agreement for mean arterial pressure(MAP) in all five critical care units , in different hours <12,12-24,24-36, 36-48 hours ranged from -20.11 to +20.69 mmhg. With the average of the paired t-test of 0.30 in relation to $p \leq 0.05$. These limits of agreement seem higher than what has been suggested by Bruya and Demand and other studies as to what is acceptable as frame of reference between IBP and NIBP (Liehr & Dedo 1995; Parati, Boli & Manci, 2004; Pytte, et al, 2006).

Baseline assessment information

Patient physical assessment still a primary, cornerstone of nursing care, especially during this rocketing medical technology, one can still rely on good, comprehensive patient physical assessment (Pinsky & Payen, 2005).

Before BP measurement some parameters that are physiologically related to BP were assessed and recorded, these included, heart rate, temperature, positive pressure ventilation settings like peak inspiratory pressure, Pause inspiratory pressure, and PEEP (Positive ended-expiratory pressure).

Positive ventilation increases intrathoracic pressure and reduces cardiac output and affects blood pressure (Isaacson, Smith-Brair, Clancy, & Pierce, 2000; Luiz-Marcelo, Malbouisson, Brito, Jose, Camona, Otavio & Auler, et al, 2006; Pizov, Cohen, Weiss, Segal, Cotev & Perel, 1996; Theres, Binkau, Laule, Heinze, Hundertmark & Blobner, et al, 1999).

Heart rate increased during arrhythmias (atrial fibrillation, supraventricular tachycardia and other cardiac conditions) or when cardiac output and the blood pressure are deranged, the heart rate will react immediately, according to Frank-Starling theory (Chlochesy, et al, 2000; Fouche, 2001).

High temperature is associated with vasodilatation and therefore drops the blood pressure by dropping filling pressure and cardiac output (Chlochesy, et al, 2000).

Clinical factors that influenced the relationship and discrepancies between IBP and NIBP.

Inotropic/vasopressor support

Drugs like adrenalin, phenylephrin, dobutrex, nitroglycelin(TNT) have an impact on blood pressure invasive and non invasive in critical care patients as they increase or lower the blood pressure by increasing cardiac contractility, vasodilators and vasoconstrictors. These drugs are widely used in CCU as they play an important role in resuscitation and progressive maintenance of hemodynamic checks and balance.

In this study 55% (n=44) of the sample were on inotropic/vasopressor support such as adrenalin, phenylephrine, dobutrex and nitroglyceline. According to many studies these drugs have an effect on blood pressure in that they cause vasodilatation or vasoconstriction of blood vessels: Beale, Hollenberg, Vincent & Parrillo, 2004; Chlochesy, et al, 2000; Fouche, 2001).

In this particular study the Bland and Altman‘s (1986, 2003) plots and limit of agreements were done between IBP and NIBP on patients who were on inotropic/vasopressor support and those who were not on any form of inotropic/ vasopressor. The findings indicated that there was no much influence caused by inotropic support on systolic, diastolic, and mean arterial blood pressure. It is assumed that most probably due to low doses of inotropic/ vasopressor being administered in the units. The limits of agreement of systolic BP on inotropic/vasopressor support ranged from -33.79 mmhg to 34.34 mmhg. Systolic BP for those patients without inotropic/vasopressor support ranged from -27.55 to 34.92 mmHg.

From these findings, it is clear that there is no clinical significant difference caused by inotropic/ vasopressor support.

The limits of agreement of diastolic BP on patients who were on inotropic/vasopressor support was ranging from -20.56 mmHg to 17.84 mmHg. While diastolic BP without inotropic/vasopressor support was ranging from -16.51 to +20.51 mmHg, it is evident that there was no significant difference caused by inotropic/ vasopressor support.

The same applied with mean arterial pressure the limits of agreement of MAP on patients who were on inotropic/vasopressor support ranged from -17.83 mmHg to +17.00 mmHg. While MAP on patients who were without inotropic/vasopressor support ranged from -16.58 to + 20.94 mmHg.

The above results are in line with some previous studies who found no difference of blood pressure in patients receiving low dosages of inotropic/vasopressor support and those without it. Bur, et al (2003) found that low dosages of less than 0.1 micrograms of adrenalin did not contribute much to inaccuracy of the measurements in larger group of patients.

Mechanical ventilation with PEEP

In this study 81.25% (n=65) of the sample were mechanically ventilated with PEEP and the rest 18.75 % (n=15) were on oxygen via face mask. According to previous studies mechanical ventilation with positive pressure has an effect on blood pressure by dropping the blood pressure (Pinsky & Payen 2005). In this study there was no much difference caused by mechanical ventilation with peep as the limits of agreement on systolic BP on patients with mechanical ventilation with peep ranged from -31.50 mmHg to +32.95 whereas those not on ventilator ranged from -23.52 to +40.18 mmHg . There was no much difference in diastolic and MAP as well. These findings are in line with some of the studies that found no difference at all on patients with or without mechanical ventilation with PEEP, they stated that unless the positive pressure ventilation is above 20 cm H20, it does not impair significantly on ventricular performance (Pizov, et al, 1996; Van den berg, Grimbergen, Spaan & Pinsky, 1997).

Sedation and analgesia

These are drugs that are widely used in CCU especially for patients who had surgery and consequently ended on mechanical ventilation. Many patients in CCU tend to be very agitated, restless in pain and uncomfortable. Various types of sedation and analgesia are used to manage these conditions. However these drugs have a great impact on blood pressure, as they act on central nervous system and sympathetic or parasympathetic nervous system, some of them cause vasodilatation like morphine or dormicum; Chlochesy, Breu, Cardin et al., (2000). 46.25% (n=37) patients were on sedation /analgesia and the rest 53.75% (n=43) were not on sedation/ analgesia. The limits of agreement of these two sets of blood pressure did not differ much to give us reason to suspect the influence of the analgesia /sedation on blood pressure differences. The limits of agreement of systolic BP for patients who were on sedation/ analgesia ranged from –36.27 and +34.41 mmHg. The sets of SBP, DBP and MAP did not differ much as well ,which is in line the other study stating that small doses of analgesia do not significantly affect the blood pressure.(www.icu-usa.com/tour/procudures/sedation.htm Accessed on 22 /5 /2010 with unknown author.

The severity of illness (APACHE II score)

The severity of illness was divided in two groups: the APACHE II score of below 30 and the APACHE II score of above 40. The patients with APACHE II score below 30 were 64 while the rest with APACHE II score of above 30 were16. according to previous studies, the severity of illness affect the blood pressure (Pytte, et al., 2006) but in this study the difference caused by the severity of illness is no that evident according to the limits of agreement and paired t-test. (Pytte, et al., 2006) instead Pytte and Dybwik found that the discrepancy between the two methods increased with disease severity (Araghi, et al., 2006).

The systolic blood pressure with apache below 30 had limits of agreement that was ranging from -30.53 to +35.25 with p-value of 0.017<0.05 the systolic blood pressure of the apache of above 30 had limits of agreement that was ranging from -31.51 to +35.51 with p-value of 0.16>0.05 . The diastolic and MAP are also almost the same irrespective how much is the severity of illness. It can therefore be concluded that the inotropic/vasopresor, sedation/analgesia, mechanical ventilation with PEEP, and severity of illness did not affect the difference of the IBP and NIBP.

According to previous studies on comparison and testing the limits of agreement of two blood pressure methods, the possibility of making incorrect clinical decision based on the blood pressure measurement increases with the discrepancy of the two methods. A discrepancy of greater than 10mmHg in critically ill patients is considered clinically unacceptable, as it could lead to improper treatment in the form of unnecessary vasopressor therapy or failure to start such treatment (Liehr, et al 1995; Pytte, et al., 2006). In light of the above previous studies, the discrepancy of IBP and NIBP in this study is way above 10 mmHg in systolic, diastolic and mean arterial pressure.

The comparison of limits of agreement of systolic blood pressure are wide reflecting the great variation of the differences and poor agreement of the mean of systolic underestimation of -30.89 mmHg and the mean of systolic overestimation of +34.05 mmHg, while the mean of the mean difference (bias) is 1.60. Similar results have been found before and the reason of that wide discrepancy was attributed on the difficulty to keep the invasive catheters patent the use of inappropriate cuff sizes, patient's movement during the blood pressure measurement (Araghi, et al., 2006).

The comparison of limits of agreement of diastolic blood pressure are wide reflecting the great variation of the differences and poor agreement of the mean of diastolic underestimation of -19.92 mmHg and the mean of systolic overestimation of +20.13 mmHg, while the mean of the mean difference (bias) is 0.10. Previous studies found almost similar findings. (Araghi, et al., 2006; Parati, et al., 2004).

The comparison of limits of agreement of mean arterial blood pressure are wide reflecting the great variation of the differences and poor agreement of the mean of MAP underestimation of -20.11 mmHg and the mean of MAP overestimation of +20.69 mmHg, while the mean of the mean difference (bias) is 1.14 as shown by the summary below. (Bruya and Demand, 1985; Parati, et al, 2004).

According to Araghi and Guzman (2006); Bur and Herkner (2003); Bruya and demand (1985); Pinsky and Payen (2007); all suggested that 10 mmHg is the acceptable frame of discrepancy between IBP and NIBP. According to many studies the IBP remains the gold standard blood pressure measurement technique in critical care unit provided that it is used correctly. In light of the above findings, the assessment of the limits of agreement between IBP and NIBP using Bland-Altman analysis indicated that the 95% limits of agreement between these two methods demonstrated high level of disagreement that includes clinically important discrepancies of + or - 40mmHg which is way above the 10mmhg frame of reference according to studies .Therefore we can clearly draw a conclusion that IBP and NIBP cannot interchangeably be used in critical care unit before 0 h to 48 hours of arterial line insertion. This conclusion is in line with other published studies on blood pressure measurements (Araghi, et al., 2006; Parati, et al., 2004).

The **second part** of this study was to elicit the reasons given by clinical practitioners (Doctors and nurses) for their choice of blood pressure monitoring techniques in the critical care unit. 80% (n=40) of the clinical practitioners responded that the IBP was more accurate than NIBP in critically ill patients while 20% (n=10) clinical practitioners of the sample chose the NIBP over IBP.

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 traditional known as accurate method of blood pressure measurement (Clark, et al 2002). Some respondents also said that they trust NIBP as it can give a quick reflection of hemodynamic status that can prompt a clinical practitioner to take relevant and suitable action without unnecessary delay. They all insisted that proper calibration, leveling and zeroing and other precautionary measures before declaring it accurate and reliable.

Twenty per cent (n=10) of the clinical practitioners preferred NIBP over IBP. Their reasons were that with the shortage of skilled nurses and understaffing of most of 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.

4.5 SUMMARY

This chapter dealt with the results obtained from the study and discussed the descriptive and inferential statistics used to describe and analyze data. This has been presented in the form of descriptive, tables, scatter plots and graphs to enhance interpretation of the results.

The following chapter will present a summary of the study, the main findings, conclusions and recommendations.