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Knowledge and practice on invasive arterial pressure monitoring: A study on critical care nurses in order to evaluate the effectiveness of an arterial blood pressure monitoring guideline

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Abstract
Background: One of the clips of Critical Care is close monitoring and intensive care for complex issues to Critically ill patients. Monitoring of blood pressure is one of the most fundamental requirements in the ICU and it impacts a lot on understanding patient's status to take timely decision for any intervention. The cannulation of a peripheral artery to measure Intra-arterial blood pressure (IBP) is often considered the gold standard of blood pressure measurement. Nurses posted in critical care areas and documenting arterial pressure without having much understanding the fundamentals of invasive pressure monitoring often has seen. It becomes challenging when there is a dampened wave or any other trouble shooting status reflected on the hemodynamic monitor.

Purpose: The study aimed to determine the existing level knowledge and practice of nurses on arterial pressure monitoring in order to develop a guideline and to validate the same for the purpose of accurate and safe practice while caring patients in Critical care areas by the nurses.

Methodology: The quasi experimental research approach was adopted among 100 Nurses posted in two critical care areas with similar set up. Data were collected by using a structured knowledge questionnaire and a structured Practice criterion check list on Arterial Pressure monitoring. All Nurses were included in the study. Both Descriptive and inferential statistics were used to analyze the data.

Results: In the research study it was observed that 28 (28%) of Nurses are at the age group of 21 to 25 years, (48%) were 26-30 years and >31 years only 24(24%) Nurses. 76(76%) were female nurses and 24(24%) were male nurses participated for the study. Majority of the nurses were arts back ground joined nursing. 47(47%) of Nurses were having 1-3 years of Nursing experience where as 60% Nurses were having 1-3 years of critical care experience. It means Nurses without experience to other areas directly posted at critical care areas. And Majority (85%) of Nurses have never attended any Hemodynamic monitoring workshop or training before appointed in Critical care. Knowledge of the nurses were assessed by mean percentages and SD which has shown, mean pre-test knowledge score of Nurses is 5.78, (the knowledge questionnaire carries to total 20 marks)Standard Deviation (SD) 2.42. Mean pre -test practice score is 11.13 and SD 3.18 (The practice observation checklist carries total 15 marks). The Mean post-test knowledge score 19.40 and SD 0.86 after implementation of the guidelines on arterial blood pressure monitoring), and the post-test Practice score is 14.46, with SD 1.22. A paired samples t-test used, which showed that the participant's level of Knowledge on Arterial pressure monitoring after implementation of guidelines increased from pre-test (M = 5.78, SD = 2.24) to post-test (M = 19.4 SD = 0.86,), Paired difference mean 13.62, with SD 2.64 and Pair t test = 51.53, $p<.001$, df = 99, and practice score showed that the participant's Practices on arterial pressure monitoring after implementation of guidelines increased from pre-test (M = 11.13, SD = 3.18) to post-test (M = 14.46 SD = 1.22; pair difference Mean 3.33 and SD 2.29, t = 14.53, $p<.001$, df = 99. Hence the data proves that implementation of Arterial pressure monitoring guidelines significantly improved Critical care nurse's knowledge and practices. Hence the Null hypothesis was rejected and research hypothesis was accepted. A bivariate Correlation computed with person test between age of the nurses and pre-test knowledge score, which showed significant at $p<0.05$ level, (p = 0.041), whereas pre-test knowledge with years of experience and Critical care experience is not significantly corelated at $p<0.05$.

Conclusion: The understanding and accurate interpretation of patient's hemodynamic status is paramount important. Continuous training with guidelines helps to interpret the technique of Arterial pressure monitoring. The researcher has seen in this study that Nurses has significantly improves their knowledge and practices.

Keywords: Arterial pressure monitoring, critical care areas, critical care nurses

Introduction
Arterial pressure monitoring is one of the components of Hemodynamic Monitoring. This can be monitor by using Noninvasive and invasive technique. The accuracy of pressure measurement via non-invasive technology still not considered to be so effective in terms of

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understanding the actual mean pressure. The Invasive monitoring is the best means of measuring of pressures while patient's compromised with hemodynamic status. The invasive monitoring of Arterial Blood pressure (ABP), with the help of invasive line and transducers, fluid filled system and monitoring devices needs meticulous preparation and Insertion of an Arterial line otherwise called as Art-line, A-line, Intra-arterial line. An arterial line is used to take continuous BP readings and is called as intra- arterial blood pressure monitoring (IAP/IABP). The Nurse working in the critical care unit need to understand the Anatomy and physiology of the Cardiovascular system & systemic vascular Resistances and physiology of Arterial pressure. Effective monitoring of arterial pressure as a hemodynamic parameter can give actual performance of the patient's condition which permit analysis of key circulatory functions and the anticipation of deterioration so that pro-active treatments can be initiated. Despite its increased risk, cost, and need for technical expertise for placement and management, its utility in providing crucial and timely information outweighs its risks in many cases. Nurses posted in Critical care unit needs to be well versed with the equipment required to insert an arterial line, transducer setup, fluid filled system hemodynamic Monitor, the arterial wave, importance of diacrotic notch and the measures required to take during trouble shooting condition. The complications related to Insertion maintenance and removal of arterial line to be understood for the safety of the patient. The researcher here would like to understand the Nurses Knowledge and practice of Arterial pressure monitoring working in Critical care areas.

Need of the study: Nurses posted in Critical care areas needs to understand the arterial pressure monitoring, because it provides critical information about patient's cardiovascular system and helps them make timely clinical decision. Often it is seen that, Nurses are not having confidence with knowledge and Practice while looking after patient with arterial pressure monitoring devices, specially the importance of wave formation, diacrotic notch, the mean pressure and its importance. Hence the researcher would like to develop guidelines to measure the effectiveness while caring patients with arterial line.

Purpose
The purpose of this study is to evaluate the knowledge and practice of Critical care Nurses on Arterial pressure monitoring as a part Hemodynamic Monitoring. The nurses here will be able to understand the details of wave formation and the required measures nurses will take to avoid complication while a patient is on arterial line and on continuous pressure monitor. Based on the knowledge and practice the researcher will prepare a guideline for the nurses for the future reference and will measure its effectiveness.

Objective: The objective of the studies are
1. To assess the Socio-demographic profile of the Nursing personnel working in Critical care unit.
2. To assess the existing level of knowledge and Practice of Nursing personnel working in Critical care unit on monitoring of Arterial pressure.
3. To assess the post interventional level of knowledge and Practice of Nursing personnel working in Critical

care unit on Arterial pressure monitoring.
4. To evaluate the effectiveness of ABP monitoring guidelines on knowledge and Practice of Nursing personnel working in Critical care unit.
5. To find out the correlation of demographic factors with Pretest knowledge and Practice score of Nurses working on Arterial Blood Pressure Monitoring.

Hypothesis
H0: There will be no significant difference between mean pretest and Post-test knowledge & Practice Score of Nursing personnel working in Critical care unit on Arterial pressure Monitoring parameter.

H1: There will be a significant difference between mean pretest and Post-test knowledge & Practice Score of Nursing personnel working in critical care unit on Arterial pressure Monitoring parameter.

H0: There is no correlation with the Total years of experience, Critical care experience and pretest knowledge & Practice Score of Nurses working in Critical care Unit with Arterial pressure monitoring.

H2: There is a correlation with the Total years of experience, Critical care experience and pretest knowledge score & Practice Score of Nurses working in Critical care Unit with Arterial pressure monitoring

Assumption
- Nursing personnel working in Critical care unit have some knowledge regarding arterial pressure monitoring.
- Nursing personnel working in Critical care unit are able to measure different parameters of arterial pressure.
- Nurses with years of experience will have some knowledge on arterial pressure monitoring
- Experienced Nursing personnel will have better practice in Critical care areas.
- Experience Nursing personnel will be able to interpret hemodynamic changes in critically ill patients.

Inclusion Criteria
1. Critical Care Unit of the Hospital (ICU, All Medical ICU, all Surgical ICU)
2. Nurses working in Critical care Unit
3. Only Invasive hemodynamic monitoring with Arterial line will be included here
4. Minimum 6 months experience staff will be included
5. Critical care specialized or cardiovascular Specialized staff will be included
6. Only registered staff nurses employed in Critical care areas will be included.

Literature Review
Review of related literature is an essential step in the development of a research project. Which helps the investigator to gain insight and developed a deeper understanding to the various aspect of the problem.
Michele P (2014) [1] Narrated that the objective of hemodynamic monitoring is to ensure optimal tissue perfusion and oxygen delivery while maintaining adequate mean arterial blood pressure. The researcher here stated that during invasive hemodynamic monitoring, the level of the right atrium is the standard zero reference point

and is identified by the phlebostatic axis—the intersection of the midaxillary line and the fourth intercostal space. The researcher emphasized the nurse will "level" the system using a carpenter's level or laser-light level to align the patient's phlebostatic axis with the transducer. Repositioning the patient may artificially alter waveforms by applying pressure to the catheter, shifting the catheter or stopcock, or shifting the phlebostatic axis relative to the transducer. The transducer is releveled when clinically indicated. Raising the level of the phlebostatic axis relative to the transducer gives false high readings; lowering the phlebostatic axis gives false low readings.

Gianluca V (2019) [2] *et al* stated that Evolution in technology has introduced into the clinical practice easier, less invasive, and more rapid systems for CO estimation. Among them, pulse contour methods are minimally invasive systems that analyze the arterial pressure waveform from an indwelling arterial catheter and allow the estimation of the patient's stroke volume (SV) and CO.

Jeshvaghani, T A (2021) [3] in her study on "Nurses' Educational Needs Assessment for Hemodynamic Monitoring in Intensive Care Units" mentioned that Hemodynamic monitoring is widely accepted as a cornerstone of intensive care units (ICUs).

The researcher here used descriptive–analytical approach to evaluate the educational needs assessment of ICU nurses in terms of the hemodynamic monitoring. The research sample included 100 ICU nurses selected from the hospitals affiliated to Shahid Beheshti University of Medical Sciences, Tehran. Researcher-made observational checklist and questionnaire of clinical reasoning skills were used to assess the educational needs for hemodynamic monitoring. The findings from the clinical practice checklists on hemodynamic monitoring revealed that nurses' practice was moderate in all 10 cases of monitoring with a mean of 79.30% (SD = 15.32%). Moreover, the nurses included were given a 9-item questionnaire regarding clinical reasoning skills. Accordingly, the results of this questionnaire indicated that nurses' clinical reasoning skills were at a poor level with a mean of 52.56% (SD = 8.71%). The findings suggested that the development of continuing education programs in the area of clinical reasoning skills for hemodynamic monitoring should be more emphasized on. Also, nurses need to learn how to examine the patient carefully, find nursing diagnoses, set goals of care, and plan nursing interventions for their patients.

B H McGhee & S L Woods (2001) [4] stated that Direct monitoring of arterial blood pressure provides continuous, real-time information about patients' physiological status. Critical care nurses set up and maintain monitoring systems and use the obtained data to guide clinical decisions. Inaccurate measurements may lead to misdiagnosis and mismanagement. The purposes of the research study was to describe critical care nurses' knowledge in 3 content areas related to direct monitoring of arterial blood pressure: physiology, technical aspects, and waveform and data interpretation. In this study Via poster advertisements, 391 critical care nurses in 6 intensive care units at 2 hospitals were invited to complete an 18-item, criterion-referenced questionnaire on monitoring arterial blood pressure and a demographic data sheet. The result has shown that the Scores ranged from 11.1% to 61.1% correct answers, with a mean of 36.7% (SD, 11.8%). Item analysis indicated a knowledge deficit in all content areas at all cognitive levels.

Questions with highest scores addressed waveform damping and using mean arterial pressure to guide treatment; lowest scores were related to dynamic response characteristics and reflected pressure waves. Mean scores did not differ among demographic subgroups. The results suggest a general knowledge deficit in arterial blood pressure monitoring among Nurses.

The conceptual framework in this research study used is based on general system theory of Ludwig von Bertalanffy. It is a system theory model uses functional graph that establish the input outputs and task processing required to send input into outputs. Input refers the Critical care unit, Nursing personnel working in intensive care unit, the process, hemodynamic monitoring devices and equipment. Demographic profile of the nurses Age, Sex, Professional qualification, Years of experiences. The throughput includes the development of questionnaire to assess the knowledge of nurses and observation checklist to assess the existing practice of arterial pressure monitoring, as pre-test, assessing the knowledge and practice with the help of those tools. In the development of Arterial pressure monitoring guidelines validity and reliability were established as part of process. In the output the guidelines were also administered to the nurses and post-test was taken to assess knowledge and practice of Nurses working in Critical care areas.

Research approach: Quantitative Research approach has used. The primary objective of the study was to assess the level of Knowledge and practice among the Nurses working in critical care areas on ABP monitoring, with a view to develop and evaluate the effectiveness of a ABP monitoring guidelines.

Research design
Research design adopted in this study pretest and posttest design Initially as pre-experimental design, later with the validator feedback and ethical committee suggestions control group also has been taken for the study.
Hence the design of the study used Pretest post-test control group design.

Pretest – post test control group design
Measurements of the outcome or dependent variables are taken both before and after the intervention. This allows the measurement of change in individual cases

R	O_1	X	O_2	Experimental group

Here R – Respondent or the participants for the Research study
O_1- Pretest knowledge and practice score of experimental groups
X- Introduction of Arterial pressure monitoring Guidelines
O_2- Posttest knowledge and Practice of Experimental group

Variables
Demographic Variables were Age, sex, professional qualifications and year of experiences.

Dependent variable: The dependent variable in this study was the knowledge of the Intensive care Nurses regarding Arterial blood pressure monitoring and the practice of Intensive care Nurses regarding ABP monitoring of patients admitted in Critical care unit.

Independent variable
The independent variables in this study is the arterial blood pressure monitoring Guidelines.

Setting: The study conducted in different critical care setup of a Hospital with similar Infrastructure, with bed capacity of 330 with 125 ICUs bed which comprises of Medical Intensive Care, surgical Intensive Care, Respiratory Intensive Care. All Patients are here with Hemodynamic Monitors. Nurses were 24x7 Posted in three different shifts to care patient. The primary Nursing allocations follows in all areas. The standard operating process are follows same in all Critical care.

Population: for this study all Nurses working in the Intensive care of the selected hospital comprised of the target population and they are the Registered Nurses (Registration No from Nursing council) who could who were allocated with patients having arterial line and on continuous hemodynamic monitor.

Sample: In this study, sample consisted of Nurses those who were available in intensive care unit during the period of data Collection. Here each nurse has taken as a sample for the study in divide in control and experimental group.

Sampling technique: Convenience sampling used. Total 100 Nurses were included from two Critical care units.
The inclusion criteria were Nurses working in Critical care Unit allocated for patients with Arterial pressure monitoring on hemodynamic monitor. All age group and experiences were included and the exclusion criteria were except Critical care Units other areas of the hospital, non-invasive monitoring, Nurses from ward if posted for helping, Nurses undergoing induction programme excluded in the study.

Tools are used for data collection
Tool 1: Demographic proforma consisted of all demographic variables under the study

Tool 2: A structured knowledge questionnaire on Arterial pressure monitoring. There were total 20 questions prepared and Clear direction has given to answer each question. Each correct response carries 1 mark and one incorrect response carries 0 marks. Each answer keys were prepared as multiple choice. Each item unit was constructed on the basis of the blue print of the knowledge questionnaire. Content validity were established from 12 expert in the field of Nursing & Intensive care. The reliability of the questionnaire was computed by test -retest reliability technique, using Pearson product moment correlation coefficient, which was 0.95 indicating that the tool is reliable

Tool 3: A structured Practice criterion check list on Arterial blood pressure monitoring. He checklist was rated on three headings namely Done, not done and remarks to measure the practice of measuring Invasive Arterial blood pressure by Nursing personnel working in Critical care unit. Each done item carried 1 mark, and not done item carried 0 marks. The check lists were given to the experts for the content validation. There were 99% agreement with all the observable statement, one of the experts suggested to modify the observation of arterial wave form, because the

observer will not be able to understand whether the participant is identifying the waveform

Pretesting of the structured observation checklist
Pretesting of the structured observation checklist was done on 20 nursing personnel in Cardiovascular & thoracic Surgical intensive care unit. The second rater has rated along with the investigator. Reliability of the Structure observation checklist was done by interrater reliability test (% agreement) and rank difference method. There was a difference in rating in 1 item, hence the agreement percentages were 93%.

Descriptions of arterial pressure monitoring Guidelines:
The guidelines has been prepared on the following headings:
1. Description of Intra-arterial Blood Pressure Monitoring
2. The physiology of Blood pressure measurement
3. The indications of arterial pressure monitoring.
4. Types of arterial site and lines
5. Understanding collaterals by Allen test details.
6. Precaution for Arterial pressure monitoring
7. Steps involved for measurement of Arterial blood Pressure
8. Described the essential requirements,
9. Accurate measurement of the pressure requirement:
10. Steps to find Phlebostatic axis, Labeling, calibration zeroing of the transducer.
11. Positioning of the patient
12. Advantages of ABP measurement
13. Disadvantages of ABP measurement
14. Complications of arterial line insertion: Major & minor
15. Nursing responsivities
16. Contraindications of arterial line insertions

The guideline has given to 08 experts, according to their field and areas of experience. According to the content validity index [CVI]. The criteria fulfilled by the expert carried 4.5 in 4 items so the calculated score for content validity index was 0.90. According to content validity index reference 0.75 is target value. Item with value lower than that are supposed to be discarded few. In this Arterial blood pressure monitoring guidelines, the content validators also have suggested to make it more pictorial to elaborate the details, which was considered. And as per the suggestions of the guide few changes were done. The reliability of the guidelines was established by inter-rater test and Cohen's kappa reliability. In the first method the correlation coefficient was 97.15% and in the second method it was 0.92 indicating that the guideline was reliable.

Data Collection technique
The knowledge of the nursing personnel working in Critical care unit regarding arterial blood pressure monitoring of critically ill patients assessed by structure knowledge questionnaire. This was used they are on duty at the bedside after taking consent. Existing practice assessed and then guidelines were introduced by theoretical and practical session soon after pre-test followed by after 7 days the post-test has taken related to ABP monitoring in intensive care unit Observation technique adopted during pre and post test data collection.

Data analysis & Results

The descriptive statistics used for data analysis: The Frequency and percentage distribution of Nurses based on demographic Characteristics.

Knowledge of the Nurses assessed by mean and percentage of mean, SD.

Existing practices of Nurses in relation to ABP monitoring by mean and percentage of mean, SD

Inferential statistics: Paired t-test used to compare the pretest post-test Knowledge and practice score.

The correlation coefficient used to check the correlation of Knowledge and practice score with year with years of experience.

The Chi -square used to checked the association of Knowledge and Practice score with demographic variable.

Results

The descriptive statistics are depicted in table1

Descriptive statistics of Critical care Nurses	Frequency	Percentages
Age		
21 to 25 years	28	28%
26 to 30 years	48	48%
31 & above	24	24%
Gender		
F	76	76%
M	24	24%
Stream in Higher secondary		
Arts Background	60	60%
Science Background	40	40%
Designation		
Staff Nurse	84	84%
Shift incharge	16	16%
Total working experience		
1- 3years	47	47%
4-6 years	23	23%
7-10 years	28	28%
11 & above	2	2%
Experience in critical care areas		
1- 3years	60	60%
4-6 years	28	28%
7-10 years	12	2%
Previous experience on HDM workshop training		
YES	15	15%
NO	85	85%

In the research study it was observed that 28 (28%) of Nurses are at the age group of 21 to 25 years, (48%) were 26-30 years and >31 years age group 24(24%) Nurses. 76(76%) are female nurses and 24(24%) were male nurses participated for the study. Majority of the nurses were arts back group at their higher secondary those who joined nursing. 47(47%) of Nurses were having 1-3 years of Nursing experience where as 60% Nurses were having 1-3 years of critical care experience. It means Nurses without experience to other areas directly posted at critical care areas. And Majority (85%) of Nurses have never attended any Hemodynamic monitoring workshop or training before appointed in Critical care.

Knowledge of the nurses were assessed by mean percentages and SD which has shown, mean pre-test knowledge score of Nurses is only 5.78, Standard Deviation (SD) 2.42. Mean pre -test practice score is 11.13 and SD 3.18

The guide line was developed by the investigator for the nursing personnel working in Critical care. Any guideline indicates the future course of action. The guidelines were given to 10 experts for establishing its content validity.

There was 100% agreement in almost all the areas except in content area selection, and advised to make the language easier to understand by the bed side critical care nurses. The investigator again modified the languages to make it simpler to understand.

The reliability of the guideline was established by inter-rater reliability test the correlation coefficient value obtained was 96.13%.

Guidelines are explained and demonstrated. And next data was collected during post-test after 7days.

The Mean post-test knowledge score 19.40 and SD 0.86. and the post-test Practice score is 14.46, with SD 1.22.

To test the above hypothesis A paired samples t-test used, which showed that the participant's (Critical care nurses) level of Knowledge on Arterial pressure monitoring after implementation of guidelines increased from pre-test (M = 5.78, SD = 2.24) to post-test (M = 19.4 SD = 0.86,), Paired difference mean 13.62, with SD 2.64 and Pair t test = 51.53, $p<.001$, df = 99. As per the 2nd hypothesis Which shows the implementation of Arterial pressure monitoring guidelines significantly improved Critical care nurse's knowledge. Hence the Null hypothesis is rejected and research hypothesis is accepted. To test the above hypothesis a paired samples t-test used which showed that the participant's (Critical care nurses) Practices on arterial pressure monitoring after implementation of guidelines increased from pre-test (M = 11.13, SD = 3.18) to post-test (M = 14.46 SD = 1.22; pair difference Mean 3.33 and SD 2.29, t = 14.53, $p<.001$,df = 99.Which shows the implementation of Arterial pressure monitoring practice guidelines significantly improved Critical care nurse's practice score.

Hence the Null hypothesis is rejected and research hypothesis is accepted.

A bivariate Correlation computed with person test between age of the nurses and pre-test knowledge score, which showed significant at 0.05 level, (p = 0.041), whereas pre-test knowledge with years of experience and Critical care experience is not significantly corelated at $p<0.05$.

Implications
The finding of the study has implications in nursing education, nursing administration, nursing practice and Nursing research.

In education: By training the Nurses with Inservice classes and bed side teaching while they are with allocation at the beside for Critically Ill patients

In administration: The Guidelines becomes a SOPs in the unit.

In Nursing practice for adopting the accuracy of Knowledge and steps of Monitoring

In Nursing Research also further this can be a guides to do further researches

Limitation: The study is limited to only critical care setup and on Critical care Nurses

Conclusion
The Critical care nurses are continuously looking after the patient with Invasive Arterial pressure Monitors. The understanding and accurate interpretation of patient's hemodynamic status is important hence Continuous training with guidelines requires to helps nurses to interpret the technique of Arterial pressure monitoring. The researcher has seen in this study that Nurses has significantly improves their knowledge and practices. So it is expected that using this guidelines would bring changes in their daily practices of measuring selected hemodynamic parameters and improve the quality of Nursing practice in intensive care unit, and also protect the patients from inaccurate monitoring and Interpretation and interventions.

Conflict of Interest: The author declared that they have no conflict of interest

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