Effect of Peer Education Intervention and Procalcitonin Detection on Peripheral Intravenous Catheter-Related Blood Stream Infections and Associated Complications among Selected Patients at Mansoura University Hospitals, Egypt

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Abstract: The purpose of the study was to determine whether peer education using group approach focusing on knowledge and practice aimed at improving the insertion and management of peripheral intravenous catheter and procalcitonin detection could decrease the rate of peripheral intravenous catheter- related blood stream infections and associated complications. . Subjects and Methods: This study was conducted during nine months from January 2010 to September 2010 in medical, surgical, neurology, and orthopedic departments at Mansoura University Hospitals. Two categories of subjects were included in the study; A- Nurses, including (8 peer trainers, were selected based on certain criteria and 60 trainees). B-130 Patients.Three research tools were used in the study: 1-Nurses' Knowledge questionnaire regarding the insertion and management of peripheral intravenous catheter and peripheral intravenous catheter- related blood stream infections and associated complications.2- Nurses' practice checklist regarding the correct procedures for the insertion and management of peripheral intravenous catheter, and 3-Surveillance of patients with peripheral intravenous catheter- related blood stream infections and associated complications. Results: There was a significant increase of peer trainers and trainees 'knowledge and practice in all items before and after training ($p<0.05$) .There was a significant reduction in the percentage of infections in the surgical and Medical departments (p value was < 0.001 and 0.009) while there were no significant reduction in the percentage of infections in both neurosurgery and orthopedic departments. The total isolated organisms from PCABSI were 61 microorganisms most of them were Gram negative .Detection of procalcitonin by EIA showed that there was significant high level among patients with Gram negative bacterimia versus patients with Gram positive and also patients with candidal bacterimia (P-value < 0.001). Limitations for the study: This study was based only on peer trainers and trainees of Mansoura University hospitals, so, findings can not be generalized for peer trainers and trainees of all university hospitals. Conclusion: Based on the findings of this study, peer education program and procalcitonin detection was found to be effective in improving knowledge and practices of both trainers and trainees, reduction in the percentage of infections in the surgical and medical departments and no significant reduction in the percentage of infections in both neurosurgery and orthopedic departments. Recommendations: Training for peer educators needs to be an on-going process; refresher and more advanced training should be offered periodically. Retesting study should be done on a larger sample using a control group. A follow-up study could describe the aspects of the relationship that seem important from both the trainers and the trainee's perspective, this data could be used to further refine effective teaching and learning protocols. More research is necessary to assess long-term impact evaluations. A broader study across several health institutions is also recommended so as to get a sample that will be the best representative of all nurses' level could reduce morbidity and the costs of care associated with catheter-related bloodstream infections.It is hoped that this study will help in planning and improving policies for addressing issues related to the insertion and management of peripheral intravenous catheter at Mansoura University hospitals.

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1. Introduction

Peer education is the process whereby well-trained and motivated young people undertake informal or organized educational activities with their peers (those similar to themselves in age, background or interests) over a period of time, aimed at developing their knowledge, attitudes, beliefs and skills and enabling them to be responsible for and protect their own health. Peer education can take place in small groups or through individual contact and in a variety of settings: in hospitals, schools and universities, clubs, churches, workplaces, on the street or in a shelter, or wherever young people gather. The rationale behind peer education is that

peers can be a trusted and credible source of information. They share similar experiences and social norms and are therefore better placed to provide relevant, meaningful, explicit and honest information, and can makes use of peer influence in a positive way. [1]

Peripheral intravenous catheters (PIVCs) are the devices most frequently used for vascular access .A peripheral venous catheter (PVC), is a catheter (small, flexible tube ≤ 7.5cm in length) usually inserted in the veins of the forearm or hand. It is mainly used for short-term venous access in order to administer medication or fluids. Up to 80% of hospitalized patients receive intravenous therapy at some point in their hospital episode Indications include administration of medication, fluids, nutrition and blood products. [2]

The use of intravascular devices can be complicated by a variety of local or systemic infectious events. PIVCs increase hospital stay due to infection and secondary complications that include extravasations, phlebitis with prolonged use for more than 72 hours, catheter colonization, bacterimia, and septicemia. (3) It is reported that more than 250,000-500,000 intravascular related bloodstream infections (BSIs) occur in United States every year with a resulting mortality rates 12-25%. Although the incidence of BSIs is usually low, serious complications produce considerable annual morbidity because of the frequency with which such catheters are used. Blood stream infections are not only dangerous for patients but are costly for hospitals. Furthermore, the mean cost of treating single BSI in the US is approximately s 36,000. It is estimated that the annual cost of treating patients with catheter related BSIs may be as high as $2.3-28 billions. [4]

Most PIVCs related BSIs are of cutaneous origin from the insertion site that gains access extraluminally and, occasionally, intraluminally. The microorganisms that cause most healthcare associated PIVCs -related infections are found on the skin and include coagulase-negative staphylococci, *Staphylococcus aurous*, Candida spp., and some Gram-negative bacteria. [2] Several studies suggest that dedicated intravenous (IV) therapy guidelines may reduce catheter-related complications by standardizing catheter insertion technique, inspecting catheter sites daily, and rotating catheter sites within 72 hours of placement [5, 6]. Through strict adherence to these guidelines, infusion-related sepsis is believed to be largely preventable [7].

Nurses and other health care workers are the frontline defense for applying daily infection control practices to prevent infections and transmission of organisms to other patients. Although training in preventing infection is required annually by the Occupational Safety and Health Administration, nurses and other health care staff should receive additional infection control training and periodic evaluations of aseptic care as a planned patient safety activity. Nurses have the unique opportunity to directly reduce health care–associated infections through recognizing and applying guidelines to prevent hospital acquired infections among patients and protecting the health of the staff. Clinical care nurses directly prevent infections by performing, monitoring, and assuring compliance with aseptic work practices; providing knowledgeable collaborative oversight on environmental decontamination to prevent transmission of microorganisms from patient to patient. [8] Educational programs to assess knowledge of nursing staff and their performance regarding the indications for catheter use, proper procedures for maintenance of intravascular catheters, and appropriate infection control measures, should be regularly repeated and stimulated [9].Continuing quality improvement initiatives for all staff who manage intravascular catheters are recommended to ascertain compliance with catheter care guidelines [10,11]. Stringent compliance with the evidence based guidelines during insertion of peripheral catheters and catheter care has been proven to reduce BSIs. Finally, nurses should assess daily whether or not a patient still needs an intravascular access [12].

As early initiation of appropriate antimicrobials is a key to improve patients' survival [13] and identification of the isolated pathogen including antibiogram is available at least 24-hrs after samples for blood cultures was performed. So, the need for an early and sensitive indicator of sepsis is required. Physiological features such as fever, tachycardia and tachypnea have been proposed as indicators of sepsis. These findings may be sensitive, but are less specific in the diagnosis of systemic inflammation or infection [14].

Procalcitonin (PCT) is a 116 amino acid residue peptide with molecular weight of about 13 kDa. PCT itself has no known hormonal activity. Under normal metabolic conditions, PCT is only present in the C cells of the thyroid gland. In bacterial infection and sepsis, however, intact PCT is found in the blood and, more importantly, its level is related to the severity of bacterial sepsis. Today, PCT is considered to be one of the earliest and most specific markers of sepsis [15] .In healthy populations, PCT concentrations are negligible i.e. below 0.05 ng/ml. In systemic bacterial and fungal infections, plasma concentrations are raised, whereas concentrations remain fairly low in infections of viral or nonspecific cause. Recent studies have demonstrated the

potential of PCT as a parameter to guide antibiotic therapy in different groups of patients. The most frequently used medical decision points at which the use of antibiotic therapy is considered are 0.25µg/L and 0.50 µg/L depending on the patient population [16].

Serum PCT measurement relies on a quick laboratory test that has been reported to accurately differentiate between systemic bacterial infection and non-infectious acute inflammatory states, whereas white blood cells count (WBC) and serum C-reactive protein (CRP) failed to do so [17]. Moreover, it has been shown that the magnitude of PCT elevation closely correlates with outcome in critically ill patients. [18]

Studies have previously reported a difference in PCT elevation depending on the involved pathogens, especially in cases of bacterimia. However, up to now, only a few conflicting results regarding a PCT value that is able to distinguish between GP (Gram Positive) or GN (Gram Negative) bacterial infections have been provided, when considering critically ill patients with sepsis however, it has been clearly established that differences exist in the signaling pathways involved in the host's inflammatory response induced by the two bacterial species. Since PCT elevation is thought to be closely related to the host's cytokine response to microbial challenge, we assumed that differences in magnitude according to the type of pathogen are present at the onset of bacterimia. [19]

The purpose of the study was to determine whether peer education using group approach focusing on knowledge and practice aimed at improving the insertion and management of peripheral intravenous catheter and procalcitonin detection could decrease the rate of peripheral intravenous catheter- related blood stream infections and associated complications.

The specific objectives of this study were to evaluate:

1. The effect of peer education on trainees' knowledge about the insertion and management of peripheral intravenous catheter and peripheral intravenous catheter- related blood stream infections and associated complications.
2. The effect of peer education on trainees ' practice regarding the insertion and management of peripheral intravenous catheter
3. The effect of peer education and procalcitonin detection on reduction of peripheral intravenous catheter- related blood stream infections and associated complications.
4. The significance of serum procalcitonin detection to differentiate Gram positive (GP) from Gram negative (GN) bacterial infection in order to facilitate decisions concerning the initial choice of an empiric antibiotic regimen in those patients.

Research Hypotheses:

1. Knowledge of trainees about the insertion and management of peripheral intravenous catheter and peripheral intravenous catheter- related blood stream infections and associated complications will be improved after implementing peer education program.
2. Practice of trainees about the insertion and management of peripheral intravenous catheter will be improved after implementing peer education program.
3. The incidence of peripheral intravenous catheter-related blood stream infections and associated complications will be reduced after implementing peer education program and procalcitonin detection.
4. There will be a significance of serum procalcitonin to differentiate Gram positive (GP) from Gram negative (GN) bacterial infection in order to facilitate decisions concerning the initial choice of an empiric antibiotic regimen in those patients.

2. Materials and Methods

Materials

Design: Quasi-experimental study

Setting:

This study was conducted during nine months from January 2010 to September 2010 in medical, surgical, neurology, and orthopedic departments at Mansoura University Hospitals.

Subjects:

Two categories of subjects were included in the study; A- Nurses, B- Patients

Nurses:

68 female nurses were divided into two groups 1-Peer trainers -2- Trainees

Peer trainers: (eight) 8 volunteers nurses were selected from 4 previously mentioned departments, 2 from each department. Their selection were based on the following criteria: volunteer nurses ,held the position of nursing supervisors ,had Bachelor degree nursing program, received education about hospital infection control during their faculty courses, have the ability to communicate their ideas and feelings in a positive and non-judgmental way, have good interpersonal, leadership, and motivation skills, willing to learn and be open to new ideas and ways

of doing things, capable of being a good listener , able to be supervised and receive feedback and act on that to improve themselves , commitment to the responsibility, speak the same language and are familiar with the cultural norms and values of trainees, non-judgmental and open minded, and they have the ability to encourage trainees to make their own decisions based on facts. They were similar to trainees in age, background and interests [19] [20], their ages ranged from 25-39 years old, their experiences was +/- 10

Trainees:

60 volunteers' nurses who were involved and provide direct patient care in the previously mentioned setting, all of them had diploma in nursing, their aged ranged from 22-40 years old; the majority of them (88.3%) had 10-20 years experience, and most of them (91.7%) didn't attend relevant training program, and accepted to participate in the study were recruited.

B- Patients:

Patients were eligible for inclusion if they were at least 18 years of age, males and females, had no current symptoms or signs suggestive bacterimia, were not receiving immunosuppressive therapy, and were scheduled or expected to have a peripheral venous catheter for at least four days. Patients with altered mental state prevented them from giving informed consent; patients with previously inserted peripheral intravenous catheters, uncontrolled diabetes, and patients with PIVCs related infection or septicemia were all excluded from the study.

Tools of the study:

Three research tools were used in the study:

1. Nurses' Knowledge questionnaire regarding the insertion and management of peripheral intravenous catheter and peripheral intravenous catheter- related blood stream infections and associated complications.
2. Nurses' practice checklist regarding the correct procedures for the insertion and management of peripheral intravenous catheter
3. Surveillance of patients with peripheral intravenous catheter- related blood stream infections and associated complications

Tool I:

Nurses' Knowledge questionnaire was composed of two main parts: the first part included sociodemographic status of the target groups e.g. age, qualification, years of experience, attending in-service training programs, and attending infection control conferences the second part consisted of 17 main items , which include: general knowledge and patient rights, proper catheter types and materials, correct catheter site selection, use of aseptic technique, types of dressings, catheter fixation, replacement intervals and procedure, evaluation of the insertion site daily, proper inspection and maintenance of I.V admixtures, recommended replacement of I.V infusions, correct solution and situations for flushing of PIVCs, symptôms of catheter-related bloodstream infection, peripheral intravenous catheter- related complications correct catheter duration and replacement, blood culture technique, proper situations for culturing of PIVCs tips, sending catheter tip for culture, correct procedures for removal of PIVCs. Knowledge was assessed with 53 multiple-choice questions. One point was awarded for each correct answer for a total scores represent100 %. One hundred percent correct represents the highest knowledge score.

Tool II:

Nurses' practice checklist about the insertion and management of peripheral intravenous catheter, was composed of 4 main items (general action before, during, and after inserting the cannula, also ongoing cannula management), and 40 sub items /procedures which are basically required for the insertion and management of peripheral intravenous catheter. The scores were being allotted "done completely accurately and adequately" which take one grade, "done incompletely and inaccurately and inadequately or not done" scored as zero and inadequate. Each procedure included sub steps or activities. Each step was assigned one score, with total scores of 40.the total scores were distributed as: general action before inserting the cannula (15 question), during inserting the cannula (10 question), after inserting the cannula (6 question), and ongoing cannula management (9 question).

Each procedure was considered done adequately, if it was executed both correctly and on time or with the required frequency, and inadequately if it was done either incorrectly or not on time or with the required frequency. The maximum of possible score for the nurses represented 100%. Each nurse was marked “Good” if she gained scores greater than 80% of total scores, “Moderate” if her scores between 60% to 80%, and “Poor” if she gained less than 60% of total scores. Adequate level of practice was given for nurses who got score more than 60 %, inadequate level of practice given for nurses who got score less than 6o %.

Tool I and II were used to evaluate knowledge and practice of both peer trainers and trainees regarding the insertion and management of peripheral intravenous catheter pre and post intervention. Knowledge questionnaires and performance checklist were constructed and

developed by the researchers, based on Centre for HealthCare Related Infection Surveillance and Prevention (CHRISP) Peripheral Intravenous Catheter (PIVC) Recommended Practices (2010) [2], Recommendations on Prevention of Intravascular Catheter Associated Bloodstream Infections. Scientific Committee on Infection Control, and Infection Control Branch, Centre for Health Protection, Department of Health .January 2010 [3] ,and the CDC recommendations for Prevention of Intravascular Catheter-Related Infections (2002). [5]

Tool III:

Surveillance of patients with peripheral intravenous catheters, it includes: Patients' body temperature, total leukocytic count, date of insertion and removal of peripheral intravenous catheters, date of starting clinical infection, type of isolated organisms and antibiotic susceptibility testing. This tool was used to compare and evaluate the incidence of peripheral intravenous catheter-related blood stream infections and its associated complications of patients' pre and post intervention.

The independent variable was the peer education program and procalcitonin detection. The dependent variables were knowledge and practice of trainers and trainees, clinical signs and symptoms of infection among patients ,and incidence of peripheral intravenous catheter-related blood stream infections and its associated complications

Methods

Official permission to conduct the study was obtained from the director of Mansoura University Hospital to conduct the study. Tools were constructed and developed by the researchers, then, translated into simple Arabic language. Tools were tested for content validity by 5 nursing and medical faculty members' experts' staff. The purpose and nature of the study was explained to the appropriate administrative staff. A pilot study was conducted on 5 nurses for testing feasibility and applicability of the tools and modifications were done accordingly. Selection of nurses who accepted to participate was assigned to become volunteer peer trainers after explaining the purpose and nature of the study. Interview to collect nurses' knowledge about the insertion and management of peripheral intravenous catheter and peripheral intravenous catheter- related blood stream infections and associated complications before education using tool I was achieved. Observation of nurses' performance for the insertion and management of peripheral intravenous catheters was achieved through the morning and afternoon shift, each nurse was observed three times and the mean was calculated. The pre - and the post test questionnaire was the same .The questionnaire was distributed to participants and participants were given time to answer it in the presence of the researcher to ensure clarity and understanding. The right to withdraw was also given to respondents. Ethical commitment with regard to informed consent, confidentiality, and anonymity throughout the process was maintained. The names of respondents were not used in the study. The participants were informed that the findings will only be used for the study and consideration towards setting up the peer education programs.

Training of nurses to become peer trainers:

Education was conducted in the hospital setting at chosen time based on work load for the selected nurses. These nurses received education by the researcher about Knowledge and skills for insertion and management of peripheral intravenous catheters and peripheral intravenous catheters related blood stream infections and associated complications. Education included two-hour theoretical session using interactive lecture and visual material; it was based on recommended guidelines for insertion and management of peripheral intravenous catheters. [2,3,5] Demonstrations and redemonstration of insertion and management of peripheral intravenous catheters were conducted in the clinical hospital setting for two-hours when there was indication for inserting peripheral intravenous cannula to patients.

Assessment of nurses' knowledge and observation of their practice post education was conducted. For the nurses to become peer trainers, they had to obtain at least 90 %out of 100 % from theoretical courses and three consecutive times for their performance skills. Prior to undertaking any cannulation procedure, all the volunteer peer trainers had more than 90 from theoretical courses as well as practical skills. As a result, they were equipped with the knowledge and a clear understanding to convey information and necessary clinical competence about proper and correct procedures for insertion and management of peripheral intravenous catheters.

Training of trainees, since it is recommended that 12-15 students represent an effective group size [21], four groups of 15 nurses were formed; each group was conducted by two peer trainers. The peer trainers offered Face-to-face training for two-hour theoretical lecture followed by two-hour practice session for insertion and management of peripheral intravenous catheters in the clinical setting. The material used in the education sessions was prepared by the researcher who conducted the peer training sessions. The content was the same in both types of education and included recommended guidelines for insertion and management of peripheral intravenous catheters.

(2, 3, 5)

The researcher used adult-learning principles emphasizing respect, patience, and clarity as central teaching principles. The researcher displayed confidence and competence with the material and used standard teaching scripts. Finally, the researcher instilled in the learner a responsibility to continue to disseminate education to others by using their skill and knowledge in relationship with the new learner. One strategy used is teacher modeling, which is the process of building a trusting and respectful relationship.

Surveillance of Infections:

Continuous prospective surveillance of infections was performed throughout the entire study period for 130 adult eligible patients who were admitted to the previously mentioned setting for inspection of peripheral intravenous catheters related blood stream infections and associated complications. All patients were followed up from admission to discharge. A trained infection control nurse visited the unit 3 times a week and conducted on-site surveillance of health care–associated infections. A standard definition for peripheral intravenous catheter- related blood stream infections and associated complications was based on the Guidelines for the prevention of intravascular catheter related infections of Centers for Disease Control and Prevention (2002) [,5]. Surveillance of infections was obtained by means of chart review, participation in rounds, information from physicians and nursing staff, direct observation of patients for presence of any signs and / or symptoms of infections, and review of laboratory reports. The infection control nurse discusses with nursing staff and review all patients with suspected infections.

Culturing of blood:

a- Collection of blood

After proper disinfection of the skin at the site of venipuncture (by application of Povidone iodine for 1-2 min. then washing with 70% alcohol), 10 ml blood were withdrawn from adult patients. Blood samples were then inoculated immediately in to blood culture bottles (aerobic and anaerobic), transported immediately to Microbiology Diagnostics and Infection Control Unit (MDICU) laboratory and incubated at 37°C.Whenever possible blood samples were collected before antimicrobial treatment has been started. However, receiving an antibiotic did not preclude obtaining samples. [22] One blood culture was drawn for each fever episode except when the origin of the fever was not known, two blood cultures were drawn with an interval of 45-60 min. to determine if a continuous or intermittent seeding of blood stream existed [23]

b- Processing of blood

Blood culture bottles were incubated at 37°C for up to 7 days and examined daily(up to 7 days) for evidences of growth i.e. turbidity above the red cell layer , colonies growing on top of the red cells, hemolysis, gas bubbles and clots. Subculture of blood, when there was any sign of growth, was done on two sets of blood and MacConkey's agar one set was incubated aerobically and the other anaerobically at 37°C for 48h.Also, subculture was done on chocolate agar which was incubated at 37°C in Co_2 incubator for 48h. Also, in case of absence of signs of growth, blind subculture was carried out before reporting as negative. [22]. Also, subculture of the broth was done on Sabaraud' s dextrose agar with and without actidione and were incubated aerobically at 37°C. Cultures were kept minimum for 3 days before discharging as negative even if plate appeared contaminated with bacteria. Blood cultures were incubated for 4 weeks for detection of *C.krusi* and *C. glabrata* which take longer time to grow. Flat open pan containing water was placed on bottom shelf in incubator to provide moisture. Inspection for growth was done daily. [23]

c. Identification of growth:

Growing colonies were identified by: colonial morphology, microscobical examination of Gram stained film, and biochemical reactions. API 20E (Biomerieux, France) was used for identification of Gram negative bacilli. Staphylococci were identified by catalase, coagulase test and API staph. .Candidal growth was identified by Lactophenol Cotton Blue-stained preparation, germ tube test and growth on CHROM agar Candida (BBL, France).Confirmation of Candida sp. was done by API 20C-AUX (Biomerieux, France) [24]

d. Antibiotic susceptibility testing:

The sensitivity patterns of the isolated strains were detected using disc diffusion method (Kirby-Bauer method) on Muller-Hinton agar according to the recommendation of the Clinical and Laboratory Standards Institute (CLSI) [25]

Measurements of PCT level:

Serum PCT assessment is usually performed in patients with clinically suspected sepsis. Enzyme immunoassay is used according to the manufacturer's instructions. The sensitivity of the assay is less than 3.9 pg/m.(USCNLIFE)

Test principle

The microtiter plate provided in this kit has

been pre-coated with an antibody specific to PCT. Standards or samples are then added to the appropriate microtiter plate wells with a biotin-conjugated polyclonal antibody preparation specific for PCT. Next, Avidin conjugated to Horseradish Peroxidase (HRP) is added to each microplate well and incubated. Then a Tetra-methyl benzidine (TMB) substrate solution is added to each well. Only those wells that contain PCT, biotin-conjugated antibody and enzyme-conjugated avidin will exhibit a change in color. The enzyme-substrate reaction is terminated by the addition of a sulphuric acid solution and the color change is measured spectrophotometrically at a wavelength of 450 nm±2 nm. The concentration of PCT in the samples is then determined by comparing the O.D. of the samples to the standard curve.

Statistical Methods:

Analysis was done by the statistical package SPSS for windows, version 13. Descriptive statistics were expressed for number of patients by means and standard deviations and percentages for categorical variables. Comparison of percentages before and after training was done by McNemar test for nurses' total knowledge score. Individual items were not tested due to the limited sample size (8 nurses). For trainees knowledge scores individual items and total score were tested. The same methodology was applied for performance checklists. The threshold of significance was fixed at the 5% level.

3. Results:

Table (1) depicts an important increase of peer trainers 'knowledge in all items before and after training. .The total peer trainers 'knowledge was 62.5% before training and reached 95,8% after training, a difference proved to be significant at the 5% level. Before training the percentage of correct knowledge varied between 72, 7 for general knowledge and patient rights, proper catheter types and materials, and correct catheter site selection. The score was that of correct procedures for removal of PIVC (30.0%).After training, all scores exceeded 90%.

Table (1) Total mean correct answers of peer trainers 'knowledge about the insertion and management of peripheral intravenous catheter and peripheral intravenous catheter- related blood stream infections and associated complications pre- and post training (n=8)

Knowledge Items	Pre %	Post %
General knowledge and patient rights	72.7	98.1
Proper catheter types and materials	72.7	98.1
Correct catheter site selection	72.7	98.1
Use of aseptic technique	71.0	97.7
Types of dressings, catheter fixation, replacement intervals and procedure	70.0	97.7
Evaluate the insertion site daily	69.1	97.7
Proper inspection and maintenance of IV admixtures	69.1	96.5
Recommended replacement of IV infusions according to its types	68.8	96.5
Frequency of change administration sets according to types of infusions	68.8	95.8
Correct solution and situations for flushing of PIVCs	68.8	95.8
Symptoms of catheter-related bloodstream infection	68.8	95.8
peripheral intravenous catheter- related complications	64.9	93.8
Correct catheter duration and replacement	65.2	93.8
Blood culture technique	45.8	93.8
Proper situations for culturing of PIVC Tips	41.7	93.8
Sending catheter tip for culture	41.7	93.8
Correct procedures for removal of PIVC	30.0	92.5
Total	62.5	95.8

Concerning peer trainers 'practice, table (2) illustrates that there was an improvements in all items of procedures before and after training. .The total peer trainers ' practices before training was 51.1%, after training, it reached to 92.4 %, a difference proved to be significant at the 5% level. Trainers' practices regarding the care after inserting the cannula represented the highest scores (100%), followed by the care during inserting the cannula (96.3%). Ongoing and follow up cannula management represented the least scores (79.2%)

Table (2) Total mean correct answers of peer trainers' practice regarding insertion and management of peripheral intravenous catheters pre- and post training (n=8)

Procedures for insertion and management of peripheral catheters	Pre %	Post %
General Action Before Inserting the Cannula	**41.7**	**94.2**

Wash hands with soap and water	0.0	100
Collect equipment needed	62.5	100
Identify patient by first and surname	50.0	100
Identify clinical need for Cannula insertion.	0.0	100
Explain the procedure to the patient;	37.5	100
Obtaining verbal consent for procedure	0.0	100
Establishing whether patient has any known allergies.	0.0	100
Explain to the patient the importance of keeping the site clean and dry and advise of risks of infection	0.0	100
Place opened dressing / cannulation pack onto clean dressing trolley, Open sterile packs and lay out equipment within the sterile field.	62.5	100
Sanitise hands with alcohol gel or wash with soap and water		87.5
When potential site is identified position patient comfortably with appropriate limb below the level of the heart.	87.5	87.5
Removing excess hair using clippers if needed.	87.5	87.5
Apply proximal tourniquet, without obstructing arterial flow optimal time for application is 3 to 5 mins – if additional time is needed release tourniquet as vein will tend to "disappear".	100	87.5
Encourage patient to exercise limb muscles	87.5	87.5
Clean insertion site using a spiral motion from the proposed puncture site outwards with 2% chlorhexidine in 70% alcohol for 30 seconds and then allow to dry	50.0	75.0
During Inserting the Cannula:	**72.5**	**96.3**
Gently pull on skin, distal and lateral to insertion site.	100	100
Do not touch the cannula.	100	100
Do not touch the insertion site.		100
Insert cannula through the cleaned skin area at an angle of 20 degrees.	100	100
Advance until just in the vein and then lower the cannula until it is parallel with the skin	100	100
Pull the needle back 1cm and push the cannula/needle into the vein up to the hilt	100	100
In the event of unsuccessful cannulation of the vein withdraw the cannula from the puncture site and apply pressure with non woven swab	50.0	100
Remove the tourniquet and apply pressure on the proximal vein, close to the tip of the cannula.	50.0	87.5
Remove needle and dispose of immediately into sharps container.	62.5	87.5
Cap off cannula with a sterile cap or attach intravenous fluids as appropriate	62.5	87.5
After Inserting the Cannula:	**45.8**	**100**
Secure cannula with a recognized, sterile cannula dressing, ensuring it is applied correctly;	87.5	100
Cannula dressing should be, intact, dry and adherent.	87.5	100
A date and time of insertion must be applied at point of insertion.	0.0	100
Flush cannula with 1-2 ml saline if not being attached to infusion.	100	100
Document cannula insertion for each separate cannula inserted.	0.0	100
Once cannula has been removed record this document in the patient's file.	0.0	100
Ongoing Cannula Management:	**44.4**	**79.2**
Decontaminate hands before and after each patient contact	37.5	87.5
Always access cannula by cleaning with 2% chlorhexidine and 70% isopropyl alcohol, and allow drying before administering fluid or injections.	50.0	87.5
Cannula site should be inspected at least twice a day and documented in the patient' file.	0.0	87.5
If signs of phlebitis remove Cannula and refer to medical team.	100	75.0
Remove Cannula if there is no continuing clinical indication.	50.0	75.0
Replace Cannula in a new site after 72-96 hours, earlier if clinically indicated.	50.0	75.0
Administration sets should be replaced immediately after blood and blood product administration, intermittent IV antibiotics and medicines.	50.0	75.0
All other fluid sets should be replaced after 72 hours.	62.5	75.0
ALL giving sets should be labeled with date and time on commencement of use.	0.0	75.0
Total	51.1	92.4

Regarding trainees 'knowledge, table (3) shows that there was an increase in nurses 'knowledge in all items pre and post training .The total trainees 'knowledge before training was 54.4%, compared to 91.5%after training, a difference proved to be significant at the 5% level. Before training the percentage of correct knowledge varied between 85.3% for proper catheter types and materials, and 23.5% for the frequency of changing administration sets according to types of infusions .After training, all scores exceeded 90%.Nurses 'knowledge about symptoms of catheter-related bloodstream infection had the highest scores (99.0%), followed by recommended replacement of IV infusions according to its types and general knowledge and patient rights (98.6%, 98.1%) respectively. The lowest scores of nurses 'knowledge was how to remove the PIVC correctly (85.1%)

Table (3) Total mean correct answers of trainees 'Knowledge about the insertion and management of peripheral intravenous catheter and peripheral intravenous catheter- related blood stream infections and associated

complications pre- and post training (n=68)

Knowledge Items	Pre %	Post %
General knowledge and patient rights	41.9	98.1
Proper Catheter Types and Materials	85.3	97.1
Correct Catheter site selection	72.7	97.1
Use of aseptic technique	53.2	97.7
Types of Dressings, Catheter Fixation, Replacement Intervals and Procedure	68.4	97.1
Evaluate the insertion site daily	64.9	92.9
Proper inspection and maintenance of IV Admixtures	52.0	96.5
Recommended replacement of IV infusions according to its types	44.2	98.6
Frequency of change administration sets according to types of infusions	23.5	94.1
Correct solution and situations for Flushing of PIVCs	53.3	93.4
Symptoms of catheter-related bloodstream infection	79.7	99.0
peripheral intravenous catheter- related complications	33.8	95.6
Correct Catheter Duration and Replacement	65.2	93.1
Blood Culture technique	69.1	98.1
Proper Situations for Culturing of PIVC Tips	39.4	92.9
Sending catheter tip for culture	39.4	87.1
Correct Procedures for Removal of PIVC	39.4	85.1
Total	54.4	91.5

Table (4) depicts an important improvement in trainees 'practice regarding insertion and management of peripheral intravenous catheters. .The total trainees' practices before training was 43.3%, after training, it reached to 86.8%, a difference proved to be significant at the 5% level. Before training, the percentage of correct practice varied between 62.7% for the procedures that is implemented during inserting the cannula and 32.2% for general action done before inserting the cannula. After training, their practices regarding the care during inserting the cannula was 98.5%, followed by the general action taken before inserting the cannula (87.4%).Awareness of trainees about the follow up of care represented 79.7%.

This table (5) illustrates that peer education can reduce local and infectious complications of peripheral IV catheters. The overall local complication rate was 23.1% before training compared to 3.8% after training .Pain /tenderness and warmth were the most common complications of peripheral intravenous catheters before training and represented 5.4% and 4.6% respectively.

Our results showed that there were significant reduction in the percentage of infections in the surgical department (from 42.2% to 9%) and P- value was < 0.001*** and the Medical department (from 24% to 8%) and P-value was 0.009** while there were no significant reduction in the percentage of infections in both neurosurgery and orthopedic departments. (Table 6)

It is clear from (Table 7), the total isolated organisms from PCABSI were 56 microorganisms most of them were Gram negative (28 isolates which represented 50%) followed by Gram positive (19 isolates which represented 34%) and lastly 9 isolates were Candida sp. (16%).

Detection of procalcitonin by EIA showed that there was significant high level among patients with Gram negative bacterimia versus patients with Gram positive and also patients with candidal bacterimia (P-value < 0.001).

Table (4) Total mean correct answers of trainees' practice regarding insertion and management of peripheral intravenous catheters pre- and post training (n=68)

Procedures for insertion and management of peripheral catheters	Pre %	Post %
General Action Before Inserting the Cannula	**32.2**	**87.4**
Wash hands with soap and water	0.0	52.9
Collect equipment needed	80.9	91.2
Identify patient by first and surname	33.8	97.1
Identify clinical need for Cannula insertion	0.0	97.1
Explain the procedure to the patient	33.8	95.6
Obtaining verbal consent for procedure	0.0	88.2
Establishing whether patient has any known allergies.	0.0	88.2
Explain to the patient the importance of keeping the site clean and dry and advise of risks of infection	0.0	91.2
Place opened dressing / cannulation pack onto clean dressing trolley, Open sterile packs and lay out equipment within the sterile field.	66.2	95.6
Sanitise hands with alcohol gel or wash with soap and water	0.0	52.9
When potential site is identified position patient comfortably with appropriate limb below the level of the heart.	80.9	95.6
Removing excess hair using clippers if needed.	52.9	83.8
Apply proximal tourniquet, without obstructing arterial flow optimal time for application is 3 to 5 mins – if additional time is needed release tourniquet as vein will tend to “disappear”.		94.1

Encourage patient to exercise limb muscles	80.9	91.2
Clean insertion site using a spiral motion from the proposed puncture site outwards with 2% chlorhexidine in 70% alcohol (from a bottle or pre-soaked wipe) for 30 seconds and then allow to dry	52.9	95.6
During Inserting the Cannula:	**62.7**	**98.5**
Gently pull on skin, distal and lateral to insertion site.	85.3	100
Do not touch the cannula.	85.3	100
Do not touch the insertion site.	0.0	97.1
Insert cannula through the cleaned skin area at an angle of 20 degrees.	85.3	100
Advance until just in the vein and then lower the cannula until it is parallel with the skin	85.3	100
Pull the needle back 1cm and push the cannula/needle into the vein up to the hilt	85.3	100
In the event of unsuccessful cannulation of the vein withdraw the cannula from the puncture site and apply pressure with non woven swab	66.2	100
Remove the tourniquet and apply pressure on the proximal vein, close to the tip of the cannula.	66.2	97.1
Remove needle and dispose of immediately into sharps container.	33.8	95.6
Cap off cannula with a sterile cap or attach intravenous fluids as appropriate	33.8	95.6
After Inserting the Cannula**:**	**41.2**	**81.6**
Secure cannula with a recognized, sterile cannula dressing, ensuring it is applied correctly;	80.9	95.6
Cannula dressing should be, intact, dry and adherent.	80.9	95.6
A date and time of insertion must be applied at point of insertion.		69.1
Flush cannula with 1-2 ml saline if not being attached to infusion.	85.3	91.2
Document cannula insertion for each separate cannula inserted.	0.0	69.1
Once cannula has been removed record this document in the patient's file.	0.0	69.1
Ongoing Cannula Management:	**37.2**	**79.7**
Decontaminate hands before and after each patient contact	4.4	44.1
Always access cannula by cleaning with 2% chlorhexidine and 70% isopropyl alcohol, and allow drying before administering fluid or injections.	33.8	76.5
Cannula site should be inspected at least twice a day and documented in the patient' file.	0.0	88.2
If signs of phlebitis remove Cannula and refer to medical team.	76.5	95.6
Remove Cannula if there is no continuing clinical indication.	52.9	80.9
Replace Cannula in a new site after 72-96 hours, earlier if clinically indicated.	33.8	76.5
Administration sets should be replaced immediately after blood and blood product administration, intermittent IV antibiotics and medicines.	80.9	91.2
All other fluid sets should be replaced after 72 hours.	52.9	91.2
ALL giving sets should be labeled with date and time on commencement of use.	0.0	73.5
Total	43.3	86.8

Table (5) Frequency of local complications of peripheral intravenous catheters (n=130)

Complications of peripheral I.V	Pre		Post	
	No.	%	No.	%
Pain /tenderness	7	5.4	2	1.5
Warmth	6	4.6	2	1.5
Erythema	5	3.8	1	0.8
Discomfort	4	3.1	0	0.0
Tightness	3	2.3	0	0.0
Sings of Infiltration / extravasations	2	1.5	0	0.0
Sings of Phlebitis	3	2.3	0	0.0
Total	30	23.1	5	3.8

Table (6): Incidence of peripheral catheter associated blood stream infection before and after the educational training among patients (n= 130)

Department-NIR		Before		After		P value
		No	%	No	%	
Neurosurgery	(20)	10	(50	5	(25)	0.1
Surgical	(45)	19	(42.2)	4	(9)	<0.001***
Medical	(50)	12	(24	4	(8)	0.009**
Orthopedic	(15)	2	(13.3)	0	(0)	0.14
Total		43	33.1	10.0	13	<0.001***

Table (7): The Causative pathogens of PCABSI before and after the educational training

Pathogen/Department		Neurosurgery		Surgical		Medical		Orthopedic		Total
		Before	After	Before	After	Before	After	Before	After	
K.pneumonie	(12)	1	2	1	4	1	2	0 1		
K.oxytoca	(2)	0	1	1	0	0	0	0	0	
E.coli	(8)	1	0	2	0	3	2	0	0	

P.aueroginosa	(4)	1	0	2	0	1	0	0	0	28
Proteus sp.	(2)	0	1	1	0	0	0	0	0	
MSSA	(9)	2	0	3	2	0	2	0	0	19
MRSA	(10)	1	2	4	0	3	0	0	0	
Candida sp	(9)	2	1	2	1	1	1	1	0	9
Total	(56)	10	5	19	4	12	4	2	0	56

Table (8): Serum procalcitonin level by EIA

Isolate		PCT range (ng/ml)	Mean ± SD (ng/ml)
Gram negative group	(30)	0.65 – 864	435 ± 221
Gram positive group	(21)	0.08 – 216	122 ± 42
Candida group	(10)	0.06 – 172	63.8 ± 29

P value: Gram negative vs. Gram positive: <0.001*** Gram negative vs. Candida: <0.001***

4. Discussion:

The purpose of the study was to determine whether peer education using group approach focusing on knowledge and practice aimed at improving the insertion and management of peripheral intravenous catheter and procalcitonin detection could decrease the rate of peripheral intravenous catheter- related blood stream infections and associated complications. The following discussion will focus upon the findings related to the stated research hypotheses of the study.

Impact of peer education on trainees' knowledge:

Peer education programs are based on the rationale that peers have a strong influence on individual behavior. As members of the target group, peer educators are assumed to have a level of trust and comfort with their peers that allows for more open discussions of important topics (Campbell & MacPhail, 2002) [26] .Peer education programs may be empowering to both the educator (Strange, Forrest, & Oakley, 2002) [27] and to the target group by creating a sense of solidarity and collective action (Campbell & Mzaidume, 2001;) [28]

The pretest finding of the present study showed that the majority of trainees had deficiency of knowledge regarding the insertion and management of peripheral intravenous catheter, this deficiency in knowledge could be attributed to one or more of the following reasons: Lack of orientation training program related to the insertion and management of peripheral intravenous catheters prior to work, lack of monitoring ,evaluation and feedback ,lack of refreshing courses ,lack of attending nursing conferences related to infection control during work, and unavailability of infection control textbooks to be used as a nursing reference and guidance. This result is in consistent with Gardiner (2005) [29] who stressed on that , staff in surgical departments , needs more knowledge, they feel that they would benefit from regular updates on infection control measures related to appropriate use of resources but also contributes to professional profile .

It is obvious that year of experience without acquisition of updating knowledge and practice is critical if nurses and other health care professionals are to continue to perform competently in an age of rapid change and technological growth. so effective continuing education for health care providers , specially nurses is an aim essential for changing and improving professional practice, meeting the expressed needs or interests of nurses within a given practice area ,providing competency and ultimately lead to safe and effective patient care .

After peer program intervention, education and training of trainees can result in a significant reduction in rates of PIVCs associated BSI. Implementation of a program in which performance feedback is given to HCWs results in significant improvements in compliance with PIVCs- site care and a further reduction in rates of PIVCs-associated BSI. This may be due to concise presentation of each session using a simple language and advanced their information in relation to the insertion and management of peripheral intravenous catheter, their realization that a sustainable development within hospital is necessary and that needs them to maintain a balance between effective infection control and a good practice, together with to maintain patient safety. Solid background knowledge of epidemiology and microorganisms would empower nurses with sufficient confidence to question practices and depend on their own ability to make informed decisions .Also to assure quality of care which is a step of hospital accreditation.

This is consistent with (Crow 1997) [30] who emphasized on that learning is a vital educational process. If the nurses know what, when, why and how, the rate of errors will be significantly diminished, so helping the nurses to update and correct their information will help in enhancing their knowledge and skills to continue in their profession, and develop sense of critical awareness to be able to deal with peripheral intravenous catheter- related

blood stream infections and associated complications problem in a positive way. An improvement in trainees ' knowledge was obvious regarding all items post training compared to pre training. Symptoms of catheter-related bloodstream infection had the highest scores, followed by recommended replacement of IV infusions according to its types and general knowledge and patient rights respectively. The lowest scores of nurses 'knowledge was how to remove the PIVC correctly. Meers, Jacobsen and Pherson (1992) [31] mentioned and emphasized that vital part of the program is staff education. Induction courses for different groups of health care workers on first employment should include instruction on how to avoid infecting themselves or the patients they serve. The importance of reporting signs and symptoms of infections should be stressed, and application of safety measures to avoid infections. These messages should continually be reinforced by in-service education, as it will be a billiard for first attitude to be accepted at the beginning of the nurses' work.

A systematic review and meta-analysis of the effectiveness of peer education programs for HIV prevention strategy in developing countries revealed that the findings provide evidence that peer education programs are effective in improving knowledge and behavioral outcomes. These findings are encouraging and support the use of peer education programs in these settings. They also suggest that peer education can be an effective strategy for changing behavior among hard-to-reach, hidden populations. [32]

A study of 21 peer education and HIV/AIDS prevention and care projects in 10 countries in Africa, Asia, Latin America, and the Caribbean (AIDSCAP) revealed that peer education has been an effective strategy in the prevention of HIV/AIDS. Study findings documented the need for initial and reinforcement trainings, ongoing follow up, support, supervision; clear understanding of the role of peer educators and continued incentives and motivation techniques. The study also documented that peer educators must broaden their understanding of HIV/AIDS to include care of people living with HIV/AIDS and family planning. The final output of the review was a handbook of guidelines from which future peer education programs could be designed, entitled *"How to Create an Effective Peer Education Project"* (Flanagan and Mahler 1996). [33]

Impact of an educational program on the nurses' practice:

In this study, most of the trainees didn't follow the nursing procedures related to lack of nurses' awareness before the program implementation, this could be attributed to lack of knowledge and educational and training programs , lack of nurses' awareness about risk and complications of infection, lack of evaluation system, lack of time, shortage of staff, lack of necessary policy and procedures related to insertion and management of peripheral intravenous catheter- related blood stream infections and associated complications ,unavailability of Arabic procedures books , lack of job description for each nurse , overlapping of nurses activities with administrative activities , multiple roles of nurses , poor standards of individuals and low perception of the importance of infection control measures

The present study revealed that there was a highly statistical significant difference between trainees 'practice pre and posts the program implementation. Won et al [34] reported that, application of the principles of infection control is a vital part of effective day to day nursing practice an important consideration for nurses is practices that can affect health and illness. The infection control practices of nurses and other health care professionals are therefore of paramount importance. The rapidly changing in infection control systems requires nurses to posses increasing knowledge, clinical competency, greater independence, and autonomy in clinical judgments, and that, the nurses' role is a complex performance implies a specific set of knowledge that must precede the clinical practice in order to apply its principles and concepts for providing specific nursing measures

Insertion of short peripheral catheters and administration of all IV fluids and drugs have come to be regarded as a commodity service that all nurses are responsible for performing. These nurses may be direct patient caregivers, or may serve as internal consultants, educators, and advisors to the primary care staff. They are involved with outcome monitoring, policy and procedure development, and product evaluation. The goal of insertion is to reach the end of prescribed therapy with the minimal risk to patients and caregivers, using the correct amount and type of supplies, equipment, and resources by the most appropriate personnel. Achieving this goal requires inclusion of the knowledge, skills, and expertise of nurses. Nurses, who will take ownership of this area of clinical practice? Who will work to stay current in the advancing body of knowledge in this specialty practice? Who will be responsible for incorporating the infusion nursing standards of practice into hospital policy, procedures, and practice guidelines as well as education and training for all staff will help in preventing peripheral intravenous catheter- related blood stream infections. Collaboration between nurses and infection preventionists offers the best approach to reaching

the worthy goal of total elimination of all catheter-related infections in all facilities [35].

Educational measures related to PVC insertion and maintenance has proven effective in several studies. Focused aspects of education included proper insertion and maintenance, a catheter insertion cart, a checklist to ensure adherence to evidence-based guidelines, and empowering nurses to stop the catheter insertion procedure if a violation of guidelines is observed. Nursing-related care aspects include barrier precautions during PVC insertion; maintenance of site to minimize infection risk; prevention of contamination of intravenous fluids, or medication administration; maintenance of aseptic technique for dressing changes; intravenous tubing changes based on guidelines; and monitoring of patients with PVC for signs of infection [36].

Keeping up to date with evidence-based and research practices aimed at preventing health care-associated infections is an additional essential aspect of nursing care. Nursing-related implications for early detection and treatment of infection include assessing patients for signs of infection, obtaining cultures for suspected infection, providing medical treatments for sepsis, and infection-prevention measures. Awareness of the risk factors, clinical signs and symptoms, pathophysiology, and updates in the management of infection can enhance the nursing care for patients and promote best practices for infection control [37].

The incidence of peripheral intravenous catheter-related blood stream infections and associated complications

Bacterimia is a life-threatening infection whose prognosis is highly dependent on early recognition and treatment with appropriate antibiotics, so, we were aiming for detection of the impact of peer education using group approach on reduction of peripheral intravenous catheter- related blood stream infections and associated complications. Also, detection of the significance of serum procalcitonin in differentiation of Gram negative (GN) from Gram positive (GP) bacterial infection in order to facilitate decisions concerning the initial choice of an empiric antibiotic regimen in those patients Our results showed that there were significant reduction in the percentage of infections in the surgical department (from 42.2% to 9%) and P- value was < 0.001*** and the Medical department (from 24% to 8%) and P- value was 0.009** while there were no significant reduction in the percentage of infections in both neurosurgery and orthopedic departments after the educational program which is a good sign that we can apply this program on a wide scale to decrease the incidence of bacterimia in all departments.

The total isolated organisms from PCABSI were 56 microorganisms most of them were Gram negative (28 isolates which represented 50%) followed by Gram positive (19 isolates which represented 34%) and lastly 9 isolates were Candida sp. (16%).This is in accordance with Vandijik et al 2007 [14] who detected that Gram negative bacterimia represented 57% while Gram positive bacterimia represented 43% only of cases.

Improving survival among critically ill patients with bacterimia relies on a number of interventions, among which the prompt administration of the appropriate antibiotics is obviously a key feature [23]. Also, in some cases as in neonatal sepsis because of the high morbidity and mortalityantibiotic therapy is commenced soon after the onset of symptoms before diagnosis is confirmed by blood culture [15]. Thus, it has recently been shown that the so called "door-to-needle" time is a critical factor in the survival of patients with sepsis [24]. Clinical data as well as current guidelines generally help in the choice of empiric antibiotic treatment. However, some authors have reported that the antimicrobial regimen was changed in more than 25% of patients with BSI, and the Gram stain result was subsequently communicated to the physician in charge [38].

Surrogate markers are therefore needed to make the appropriate choice more rapidly [19]. The most popular of these biomarkers are C-reactive protein (CRP) and white blood cell count (WCC) but a study of dynamics of C-reactive protein and white blood cell count in critically ill patients with nosocomial Gram positive vs. Gram negative bacterimia *Vandijick et al.,2007* [15]. Concluded that increased levels of CRP and WCC suggestive for GNB, while almost unchanged CRP and WCC levels are observed in patients with GPB. However, despite the different patterns observed, antimicrobial treatment as such cannot be guided based on both biomarkers.

Procalcitonin (PCT) and other calcitonin precursors are detectable in various conditions leading to systemic inflammatory response syndrome. Among them are pancreatitis, burn, polytrauma, and most importantly, bacterial infection. PCT reflects the severity of bacterial infection and has been used as a marker for the diagnosis and therapeutic monitoring of sepsis, severe sepsis, and septic shock of bacterial origin [39].

However, in the setting of severe community acquired pneumonia, some authors found that PCT elevation was higher when S. pneumoniae was the causative microbe when compared to the so-called atypical agents such as Legionella spp. In patients with infective endocarditis, PCT elevation was also found to be significantly higher when GN bacteria, rather than GP bacteria, were recovered from blood

cultures. These conflicting results might be caused by the fact that previous studies included a broad spectrum of infections, while only proven systemic bacterial infections are considered in the present one [19].

The results of this study show that detection of procalcitonin by EIA showed that there was significant high level among patients with Gram negative bacterimia versus patients with Gram positive and also patients with candidal bacterimia(P-value < 0.001). Our results are in accordance with that of [19] who suggested that the magnitude of PCT elevation could be significantly higher in patients with GN bacterimia than in those with GP bacterimia.

This could be explained by the fact that PCT elevation is dependant directly on inflammatory mediators released by the host in response to the offending pathogen, a different pattern of cytokine response could account for such differences. This hypothesis is supported by the fact that GP and GN bacteria are known to elicit inflammatory responses that rely on different signaling pathways of the innate immunity network. This has recently been illustrated in the blood compartment [40]. Thus, it was shown that the involvement of Toll-like receptors in the whole blood response to various bacterial pathogens was highly variable and depended on the composition of their outer membrane. Composition of the outer membrane is one of the main determinants of the Gram stain result. The magnitude of the cytokine response was thus found to depend on the invading pathogen. More precisely, it has been shown that the Tumor necrosis factor-α (TNF-α) plays a pivotal and very proximal role in the cytokine response to bacteria. However, plasma TNF-α is not necessarily high whatever the causative microorganism may be [41, 42].

Limitations for the study

1. The limitation of this study is that it was based only on peer trainers and trainees of Mansoura University hospitals. Findings can not be generalized for peer trainers and trainees of all university hospitals.
2. The study did not follow-up the subjects to measure the long-term effects of this intervention on their level of knowledge, and practice.
3. A larger sample would have been better in terms of validity and reliability, and a correlational study across different University hospitals would indicate differences in terms of knowledge, and practices regarding peripheral venous catheters.

Conclusions:

1. This study was based only on peer education program was found to be effective in improving knowledge and practices of both trainers and trainees through their compliance to infection control practices related to peripheral venous catheters that allow for reduction of peripheral intravenous catheter- related blood stream infections and associated complications
2. There was a significant reduction in the percentage of infections in the surgical and Medical departments.
3. Most of isolated organisms were Gram negative and procalcitonin levels have been shown to distinguish between Gram negative from Gram positive bacterimia accurately and quickly. Since PCT measurement is available sooner than the Gram stain result, its value could be considered when discussing the choice of first line antibiotics in critically ill patients with clinical sepsis. However, clinical findings such as the suspected source of infection as well as the epidemiological should also remain the basis for the empiric choice of any antibiotic therapy.

Recommendations:

1. Training for peer educators needs to be an on-going process; refresher and more advanced training should be offered periodically.
2. Retesting study should be done on a larger sample using a control group.
3. A follow-up study could describe the aspects of the relationship that seem important from both the trainers and the trainee's perspective, this data could be used to further refine effective teaching and learning protocols.
4. More research is necessary to assess long-term impact evaluations.
5. A broader study across several health institutions is also recommended so as to get a sample that will be the best representative of all nurses' level could reduce morbidity and the costs of care associated with catheter-related bloodstream infections.
6. It is hoped that this study will help in planning and improving policies for addressing issues related to the insertion and management of peripheral intravenous catheter at Mansoura University hospitals.

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