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ORIGINAL

Peripheral Intravenous Catheter Failure in Hospitalized Patients: Bridging the Gap between Microbiological Data and Clinical Indicators and possible relevance to therapeutic targets

Falla del catéter intravenoso periférico en pacientes hospitalizados: acercamiento entre datos microbiológicos e indicadores clínicos y posible relevancia para objetivos terapéuticos

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ABSTRACT

The peripheral intravenous catheter (PIC) is most commonly used invasive technology among inpatients, frequently associated with hospital procedures worldwide. However, PIC insertion presents multiple challenges, particularly the risk for catheter-related infections (CRI), which remain a preventable concern. Additionally, catheter failure imposes financial burdens on healthcare system. The goal is to establish a baseline for peripheral intravenous catheter failure (PICF) rates and incidences as part of a larger quality improvement. A total of 450 hospitalized patients diagnosed with PICF were included in the research, with 1263 catheters examined. PICs were placed in patients across hospital wards, ICUs, emergency departments and operating rooms. Among 700 cultured catheter tips, 302 were identified as PICF. The Hospital Length of Stay (HLOS) rate density-adjusted incidence for PICF revealed 35 out of 700 tips with positive isolates. No patients were diagnosed with CRI type three, where microbial development was concordant in tip and blood cultures. However, 12 out of 35 patients had CRI-compatible local signs and symptoms had positive cultures, while 11 exhibited symptoms within 48 hours after the removal of the catheter. The research shows that PICs caused unintended removal, which increases their significance for patient safety, illness and death. Numerous positive tip cultures were detected in the absence of any clinical indications. To emphasize that avoid CRI, it is crucial to eliminate needless PICs.

Keywords: Panic Disorder (PD); Diagnosis; Agoraphobia; Symptoms; Treatment Options.

RESUMEN

El catéter intravenoso periférico (CIP) es la tecnología invasiva más utilizada en pacientes hospitalizados, frecuentemente asociada a procedimientos hospitalarios en todo el mundo. Sin embargo, la inserción de un CIP presenta múltiples desafíos, en particular el riesgo de infecciones relacionadas con el catéter (IRC),

que siguen siendo una preocupación prevenible. Además, el fallo del catéter supone una carga financiera para el sistema sanitario. El objetivo es establecer una línea base para las tasas e incidencias de fallo del catéter intravenoso periférico (FIP) como parte de una mejora de la calidad más amplia. Se incluyó en la investigación a un total de 450 pacientes hospitalizados con diagnóstico de FIP, y se examinaron 1263 catéteres. Los CIP se colocaron en pacientes de salas de hospitalización, UCI, servicios de urgencias y quirófanos. De 700 puntas de catéter cultivadas, 302 se identificaron como FIP. La incidencia ajustada por densidad de la tasa de Duración de la Estancia Hospitalaria (DHL) para FIP se detectaron 35 de 700 puntas con aislamientos positivos. Ningún paciente fue diagnosticado con IRC tipo 3, donde el desarrollo microbiano fue concordante en los cultivos de puntas y de sangre. Sin embargo, 12 de 35 pacientes presentaron signos y síntomas locales compatibles con IRC y obtuvieron cultivos positivos, mientras que 11 presentaron síntomas dentro de las 48 horas posteriores a la retirada del catéter. La investigación muestra que las CIP causaron retiradas involuntarias, lo que aumenta su importancia para la seguridad, la enfermedad y la muerte del paciente. Se detectaron numerosos cultivos positivos de puntas sin ninguna indicación clínica. Para enfatizar que para prevenir la IRC es crucial eliminar las CIP innecesarias.

Palabras clave: Trastorno de P**ánico (TP); Diagnóstico; Agorafobia; Síntomas; Opciones de** Tratamiento.

INTRODUCTION

A Peripheral Intravenous Catheter (PIC) is a kind of catheter that is thin and tubular, as well as it has a single hollow lumen that is designed to be placed into veins.[1] One of the most frequent types of vascular access devices (VAD) is the PIC as shown in figure 1, which has an annual sales volume of approximately two billion.[2] VAD for the short-term administration of intravenous liquids, medicines, blood-related materials along with imaging media and up to seventy percent of hospitalized patients need at least one PIC before their admission to the hospital.[3]

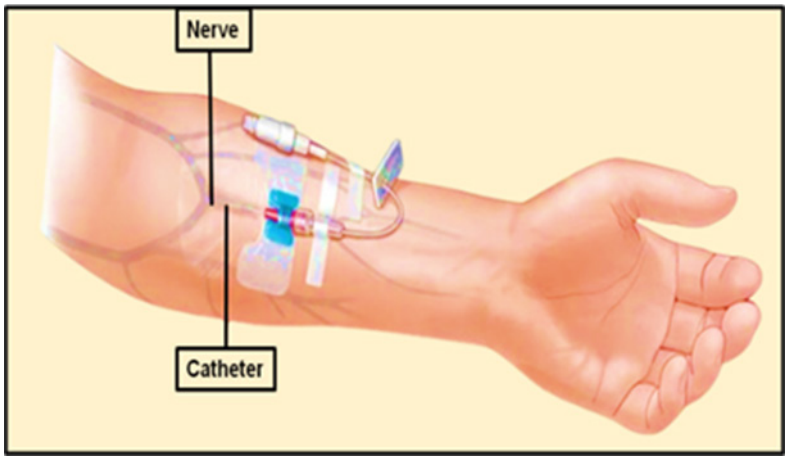

Figure 1. Peripheral intravenous catheter
Source: https://hs770.com/wp-content/uploads/2023/04/1-2-555x234.jpg.

Although it has been reported in individual research that the rate of PICF can reach as high as sixty-nine percent, the worldwide literature has never been synthesized, which could cause neglect of these rates. [4] However, even though PICs are a crucial device, continue to be vulnerable to difficulties that result in PICF.[5] PICFs are vein access systems that are used at medical facilities all over the globe to administer drugs or fluids, evaluate patients and perform medical tests on patients of all ages.[6] It is estimated that around two billion peripheral intravenous catheters are used in the treatment of hospitalized patients across the world. There are problems associated with PICF, even though it is quite common and required in many situations.[7] Peripheral intravenous catheters (PIVCs), are the most commonly used invasive device in hospitals worldwide, but the insertion, maintenance, and management during intravenous treatment can significant challenges for patients. There remains a clinical need to determine the risk factors for PVC failure and prevent catheter-related problems, as research suggest that factors such as the patient's age, the kind of catheter, the insertion site, the puncture method, and chronic illness.[8] Venous depletion, which is a condition that arises as a consequence of recurrent catheter failures, is becoming an increasingly recognized phenomenon. This condition necessitates the implantation of venous access devices that are more intrusive, dangerous and expensive.[9] The majority of patients could require the intravenous infusion of fluids or medicine at some point throughout their

hospitalization stay, which is referred as PIC, which is a therapy that is administered during hospitalization.[10]

This section reviews the existing research relevant to the research, relationship between microbiological data and clinical indicators to enhanced understanding of peripheral intravenous catheter failure, to improve patient outcomes through targeted interventions and better practices.[11] Evaluated catheter salvage rates in home parenteral nutrition patients with catheter-related bloodstream infections (CRBSI). It found that antimicrobial lock therapy significantly improved effective salvage compared to systemic antibiotics alone and focused on effective, pathogen-specific strategies to enhanced outcomes in this population.[12] Demonstrated how ultrasound-guided care methods could decrease the rate of peripheral intravenous catheter failure. Significantly lower failure rates were observed when flexible polyurethane catheters were used in conjunction with large-diameter vein selection and verification of catheter tip placements. The findings highlighted the improved assessment approaches in clinical practice.[13] Described the high failure rates of peripheral intravenous catheters (PVCs) and emphasized to require for improved practices in insertion site selection and catheter management. Identifying specific risk factors, such as catheter gauge and infusion of irritant drugs contributes to efforts to enhanced patient safety and reduced complications.[14] Highlighted the diagnostic challenges of implant-associated infections (IAIs), emphasized the limitations of standard microbial cultures and the persistence of culture-negative cases. It discussed the utility of molecular assays, including nucleic acid amplification and next-generation sequencing, as advanced tools for accurately diagnosing IAIs and identify involved microorganisms.[15] Investigated CRIs in hemodialysis patients suffering kidney transplantation by analyzing microbial diversity on catheter tips using metagenomic next-generation sequencing. The findings reveal a high detection rate of bacteria compared to traditional culture, highlighted the importance of catheter microbial composition in predicting CRI occurrences.[16] Explained the Patients suffering dialysis are particularly vulnerable to infections due to weakened immunity and the use of central venous catheters (CVCs).

The devices increase the risk of severe infections, necessitating stringent infection prevention strategies, including minimizing CVC use and considering new wireless technologies to enhance patient safety.[17] Explained the heparin saline and sodium citrate were tested as fastening solutions including ICU patients with central venous catheters. Sodium citrate prevented hypocalcemia while causing a considerable reduction in bleeding and catheter occlusion rates. Heparin, increased prothrombin and activated partial thromboplastin times, suggested that sodium citrate a better choice for the patients.[18] Highlighted the importance of clinical findings and routine blood count parameters in diagnosing catheter-related bloodstream infection (CRBSI) in chronic kidney disease patients' hemodialysis and systemic inflammation response index were observed, enabling prompt diagnosis and treatment, improved patient outcomes following catheter removal and antibiotic therapy.[19] Explained assessed metagenomic next-generation sequencing's diagnostic efficacy in patients with severe illnesses, showed high bacterial identification sensitivity and specificity was examined. In patients with impaired immune systems, beneficial anti-infective therapy changes more effectively, indicated to potential for precision medicine in infection control.[20] Investigated the incidence and risk factors for short peripheral intravenous catheter (PIVC) failure in hospitalized patients. Findings revealed that failure rate, with factors such as female gender, medical ward admission, and lower nurse staffing levels significantly associated with increased PIVC failure risk, suggesting the need for targeted interventions.

Thrombophlebitis is one of the consequences that could occur after PIC. This condition could be identified by the presence of the following symptoms or side effects: expanding, soreness, inflammation, distortion, discomfort and a large vein that looks like a string. The purpose of the research was to investigate the parameters that are connected with the function of catheter removal and positive culture of isolates, to characterize the PICF and explain pathogenic microbes that were isolated from catheter tips.

METHOD

Research aims to establish a baseline for PICF rates among hospitalized patients and to highlight the importance of eliminating superfluous PICs to reduce the risk of CRI and enhance patient safety.

Research design

The sample consists of 500 individuals who had been hospitalized for three months and had PICF. It is determined that there were a total of 1263 catheters. All of the patients who had PICF gave their permission after informed. Anonymity and confidentiality were protected throughout the process.

Management and care of the PICF

An under-recognized patient safety concern is the potential for irreparable harm to occur as a result of improper PIC implantation and maintenance. The proper care and maintenance of PIC are very necessary to avoid issues. Maintaining a sterile dressing, securing the catheter and performing routine inspections to look for symptoms of infection are all crucial. To avoid obstacles, nurses are required to perform an assessment of the site, replace dressings by the procedure and guarantee that sufficient flushing could take place. For the

best possible results for patients, it is necessary to adhere to aseptic procedures. Every single PIC was injected by nurses by the existing procedure of the organization. Chlorhexidine at a concentration of two percent was dissolved in seventy percent isopropyl alcohol to prepare the skin. A needle-free valve was attached to ten centimeters of expansion piping that terminated in a three-way connection on every one of the non-winged catheters that were used for the PICs. PIC lines are made of a small, short plastic catheter that is inserted through the skin into a vein which is shown in figure 2. These lines are implanted in the foot, hand and elbow although it could be placed in the scalp very seldom.

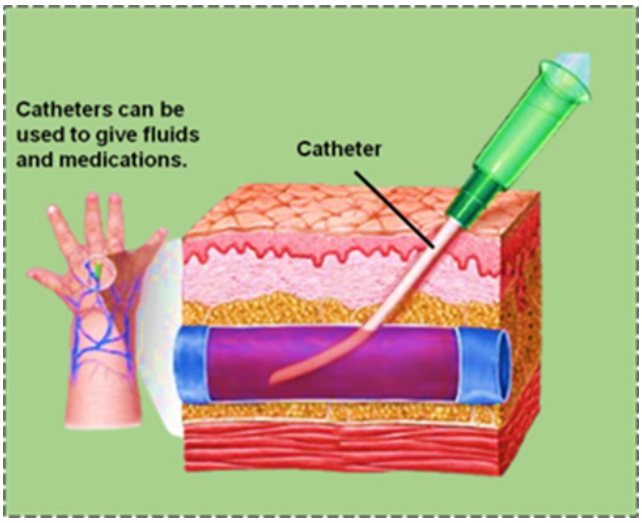

Figure 2. A peripheral intravenous line
Source: https://medlineplus.gov/ency/images/ency/fullsize/21779.jpg

To secure the PIC in place, a dressing that was transparent and had polyurethane borders was put at the insertion site. Instead of using a scrub-the-hub approach, the PICs were flushed with sterilized sodium chloride at a concentration of 0,9 % after every usage. To reduce the probability of unintentional tube disconnections, standard caps were installed on needleless connectors. PIC caps were not routinely disinfected as a preventative step, since this was not included in the official protocol.

PICF and difficulties

PICs provide crucial medical treatments and therapies to patients. Problems with PICF and its consequences are widespread. Catheter failure could arise from incorrect insertion, dislodgement, or material difficulties. To provide fluids, medicines and blood products, PICs are used in the medical field. Their broad use is accompanied by difficulties, which could end in obstructions and problems. Complications that are mechanical, such as dislodgement, infiltration or blockage, are factors that lead to PICF. Infiltration is the inadvertent release of fluids into the tissues that are around the catheter, while dislodgement happens when the catheter moves from its initial location. Any obstruction of the catheter lumen, known as occlusion, is detrimental to the flow of infusion. The patients suffering and the expenditures associated with their healthcare are both increased as a result of these consequences, which reduce the efficacy of the therapy. Medical professionals must follow strict PIC insertion, securement and maintenance procedures to overcome these issues. To address these problems, healthcare professionals are required to adhere to the protocols that are supported by evidence for the insertion and management of PIVCs. Essential components of preventative measures include the provision of appropriate care for the catheter site, the performance of routine examinations and the prompt replacement of catheters. Furthermore, developments in catheter materials and technology, such as antimicrobial-coated catheters, are in the process of reducing the probability of infection. Medical practitioners must be attentive in their monitoring of patients who have PICs, recognizing and addressing any issues that could arise. This is necessary to guarantee that these critical medical devices perform well while emphasizing the safety and well-being of patients.

Outcomes of PICF

The all-causes of PICF were defined as the removal of the PIC without prior planning before the conclusion of treatment, which was the main research outcome. Some of the reasons for PICF could be attributed to the negative outcomes that are connected with their use, which are listed in table 1. PICF subtypes (CRI, leakage, dislodgement, thrombophlebitis and obstruction), HLOS, PIC characteristics (dressing insertion side, ward and site along with setting removal), indwelling time, bacterial infection and the microbes isolated were secondary outcomes. CRI, which include the colonization of microorganisms found on catheters, pose a substantial issue

to the healthcare industry. To reduce the likelihood of difficulties, it is essential to implement preventative measures, adhere to tight aseptic regulations and intervene at the appropriate moment.

Table 1. Adverse events of PICF

No	PICF subtypes	About Side effects
1.	CRI - type 1	A positive culture was found in the tips that were removed from patients who had local indications that were consistent with a bacterial infection at the catheter insertion site.
2.	CRI - type 1 and 2	Within forty-eight hours following the removal of the catheter, the clinical indications of the main bloodstream infection and the laboratory-confirmed local PIC infection showed signs of improvement.
3.	Extravasation	The accidental release of a vesicant solution into the tissue that is around the affected area.
4.	Dislodgement	PIC is taken out of the patient's body in its entirety.
5.	Phlebitis	PIC-related chronic discomfort, inflammation, wounds and visible occlusion of the cannulated vein are all symptoms of this condition.
6.	Obstruction	A full obstruction of the PIC leads to the inability of either inhalation.

Statistical analysis

It was with the assistance of the Statistical Program for Social Sciences software program, version SPSS 21, that the processing of statistical data was carried out. Although a measure of variability range of values, standard deviation along with arithmetic mean were employed in the presentation of numerical variables, the prevalence and percentage were utilized in the presentation of attribute variables. Both of these methods were applied in the display of the variables. To determine the extent of the variation in the frequency of quality values for PICF, Pearson's Chi-square test was considered.

RESULTS

Sample results and clinical features: Research examined 700 PICs from 500 patients, the majority of whom were located in ICU wards (425). Female patients made up 230 of the totals. In the sample, the median number of PICs per HLOS was one PIC for each patient. The total number of hospital admissions had an incidence density of 1300. As far as the overall PIC/HLOS is concerned, 500 patients had one PIC whereas 130 patients had two PICs and 70 patients carried three or more PICs. 700 PIC tips were processed, the majority of which were from patients in intensive care unit wards 425. In all, 302 PICs, which account for the total, were classified 700 PICCs across 500 patients, predominantly in ICU wards 425 of the total patients, 230 were female, and the median number of PICs per patient was one. A total of 302 PICs were classified as having complications PICFs, with the most common subtypes being leakage 134 and thrombophlebitis 108, a significant rate of complications, with 75 patients diagnosed with CRIs, there were no cases where bacterial growth occurred simultaneously in both catheter tips and blood cultures from the same individual. The findings, supported by a statistical significance of $p < 0,001$, highlight the need for vigilant monitoring of PICCs, especially in critical care settings. Figure 3 shows the flow diagram of PICF.

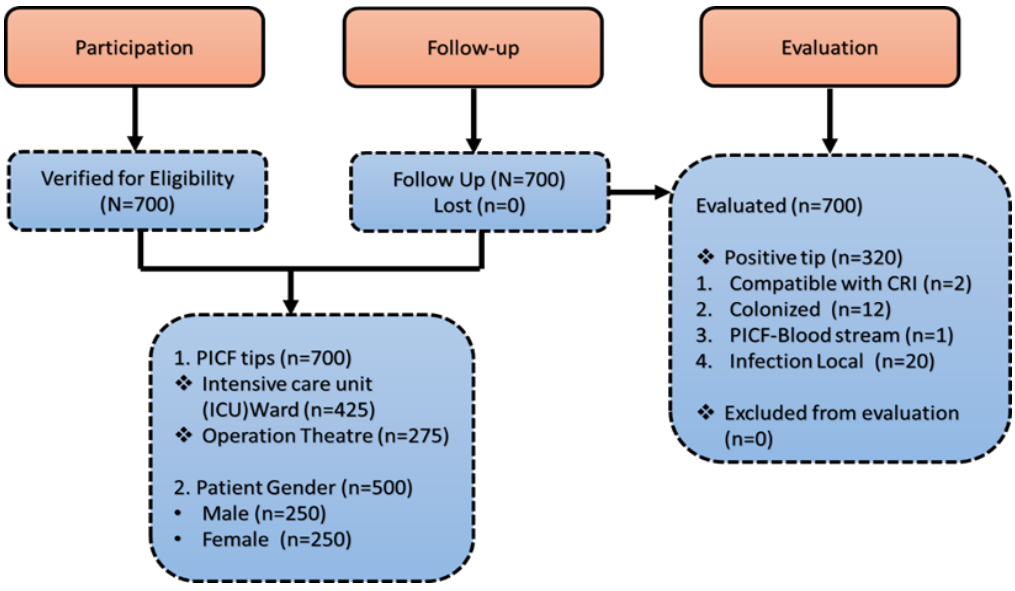

Figure 3. Flow of PICF

Table 2. PICF causes

Variables	PICF			p-value
	Rejection	Agree	Whole	
Whole PVCs, (n)	425	285	700	
1. Age years, (n)				
20–40	35	20	55	
41–60	45	65	110	0,457
60–80	146	74	220	
80 above	186	129	315	
2. Illness, (n)				
1	59	36	95	
2	125	70	195	0,687
2 above	290	120	410	
3. Fitting place, (n)				
Hand	125	70	195	
Wrist	35	20	55	
Forearm	261	180	441	0,212
Arm	2	1	3	
Foot	2	4	6	
4. Hand (n)				
Left hand	219	149	385	0,471
Right hand	175	140	315	
5. Constitutional, (n)				
48 h above	245	180	425	0,598
96 h below	185	90	275	
6. Insertion Setting (n)				
Hospital Ward	140	135	275	
ICU	45	15	60	0,231
Emergency	215	115	325	
Operation theatre	35	5	40	

Factors connected to the cause of PIC removal as it relates to positive tip cultures are described in table 3 and figure 4. Out of 35 positive tips, 12 were related to needless PICs that were removed after patients were discharged. 231 out of 35 suggestions were on PICF for leakage (9), obstruction (5) and thrombophlebitis (9). Both thrombophlebitis and leakage greater number of positive tips (9/35) were found to indicate lower obstruction (5/35).

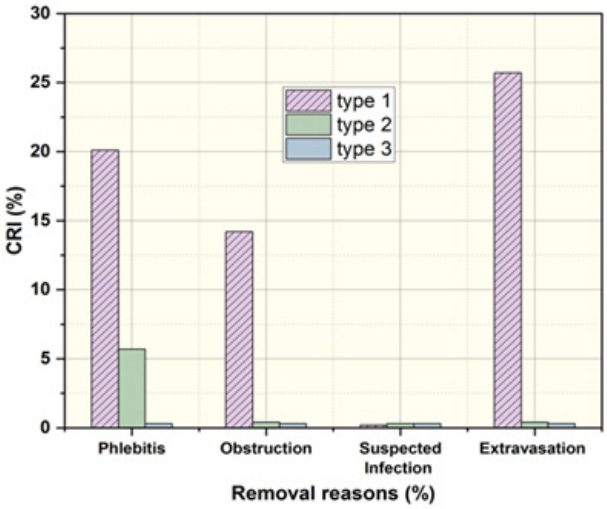

Figure 4. Comparisons of Removal Reasons

The many causes of PICF are detailed in table 2, which could be found. For the total number of PICs, there was 302/700 that resulted in catheter failure. It was discovered that patients over the age of 80 above (220/700) presented with a high prevalence of PIC unplanned removal and comorbidities were detected. In addition, all of them had two above illnesses, which accounts for 410/700 of the total. For example, 441/700 of the PICs were put into a region that did not involve flexion, such as the forearm. There were a significant number of PICs that had an indwelling period that ranged from 48 hours above before removal (425/700) and 96 hours below to removal (225/700). Primary PIC insertions occurred in emergency departments (325/700) and hospital wards (285/700). An inability to register 135 PIC insertion ward data was a result of frozen electronic records that were shared between emergency and hospital wards. Age group, illness, fitting place, hand, constitutional and clinical region of insertion did not affect PICF (p = 0,457, 0,687, 0,212, 0,471, 0,452, 0,598, 0,231). A significant association (p < 0,001) was seen between the failure of the catheter and the removal setting used.

Table 3. Numerical outcomes of Removal reasons

Removal reasons (%)	CRI (%)		
	type 1	type 2	type 3
Thrombophlebitis	20,1	5,7	0,3
Obstruction	14,2	0,4	0,3
Possible infection	0,2	0,3	0,3
Leakage	25,7	0,4	0,3

PICF, with a statistical significance of p < 0,001, as well as the subtypes of PICF, include thrombophlebitis, obstruction, leakage and dislodgement. Table 4 has a comprehensive description of the factors that are connected with clinical characteristics and outcomes.

Table 4. Characteristics and results in a clinical context

Clinical characteristics	ICU	Operation	Overall
Total patients (n)	375	125	500
Patient gender, (n)			
Female (n)	190	40	230
Male (n)	200	70	270
Total PICs, (n)	425	275	700
PIC, (n)	232/585	70/126	302/700
Secondary outcome - Subtypes of PICF			
Obstruction (n)	25	15	40
Thrombophlebitis (n)	88	20	108
Dislodgement (n)	9	4	13
Leakage (n)	97	37	134
Possible infection (n)	4	3	7
Negative tip (n)	525	100	625
CRI (n)	64	11	75

DISCUSSION

In this research, over 60 percent of PIVCs were unsuccessful, which is similar to the rates reported in another research. However, limited research has explored the occurrence of PICF following CRIs in hospital settings, primarily in medical and surgical domains, employing microbiological culture of catheter tips. With the use of this method were able to estimate with precision and dependability the rate and frequency of PICF. This included the several subtypes of PICF as well as the pathogenic microorganisms that were present on catheter tips. It is possible that the administration of intravenous medicine, in particular the significant volume of antibiotics and analgesics that are supplied fast during surgical operations, is to blame for the increased incidence of PICF, thrombophlebitis and obstruction that has been reported after surgical procedures. However, a greater PICF rate was related to the female gender in the operative context. As a result, was unable to properly trace the reason to the setting by itself which does not consider the gender variable. It is usual practice to provide care interventions such as PIC insertion treatment, preservation and administration of intravenous (IV) treatment. As a result, the failure of PIC causes a disruption in the process of intravenous treatment, which necessitates the installation of a new PIC. This circumstance has the potential to cause many difficulties,

discomfort and anxiety for patients, in addition to placing a significant demand on the resources of the health system. Nurses are required to take into account the characteristics of the patient, the kind of treatment as well as the duration of treatment, to reduce the number of devices that are installed without a necessity and to accurately match the VAD to the therapy that has been administered. At the time of their admission, the patients in research had more than two PICs in their bodies. Due to the inadequacies of the equipment, the patient could likely have an unpleasant experience and get treatment of a low quality. The potential prospect for preventing PICF and preserving arterial health lies in the presence of an algorithm capable of selecting a VAD optimally. The reinsertion of the PIC demands considerable clinical resources and time. An important number of constructive tip cultures were acquired either upon catheter exclude, following the completion of IV treatment, or during patient discharge. Notably, despite the high colonization rates, no increase in CRI rate was observed in the population. This could be attributed not only to instances of unnecessary insertions but also to the infection control team's proactive implementation of a safety culture, advocating for the prompt removal of PICs upon the completion of intravenous treatment. The recommendation to remove the catheter when clinical indications of failure arise further underscores the commitment to patient safety and infection prevention measures. When identify general symptoms that are associated with CRI, promptly remove PIC; however, this cannot ensure that eradicated the possible origin of infection. According to the findings of investigation into the characteristics of PIVC failure, discovered that there were no important shifts in the length of instant that was spent in a permanent position. Although numerous PICs isolated with pathogen microorganisms were present, the low prevalence of CRI and lack of PIC-attributable blood stream infection in research not justify accomplishing tip cultures of PICs consistently for forecasting of CRI. Removal of PICs is the treatment strategy for treating restricted clinical indicators of PICF, including as leakages, inflammations at the thrombophlebitis, and insertion site, and while keeping an eye out for the emergence of systemic symptoms. Additionally, as a highly effective treatment strategy for CRI prophylaxis, advise the early removal of superfluous PIC once intravenous therapy is complete.

CONCLUSION

The substantial failure rate of presently used intravenous catheter systems, which is illustrated in this research, necessitates that the system be questioned in today's environment, which incorporates the management of cost and resource efficiency coupled with the presence of germs that are resistant to many medicines. According to the findings of the research, approximately fifty percent of the PICs needed removal without prior planning. Even though the prevalence of potentially fatal adverse events like CRIs is very low in research, it is notable in terms of illness, death, patient security and added medical strain, particularly for nurses involved in the care of patients. It recommends that organizations place a greater emphasis on increasing the number of development initiatives in a larger whole value procedure. This process encompasses other aspects as well, such as the adequacy of the VAD and the finest care for placing of the Highlighting the importance of proactively managing intravenous therapy, specifically PICs, underscores the need for attentive maintenance and the proactive identification of opportunities for early removal to minimize unnecessary catheter usage.

Limitations

Before the interpretation of the data, it is necessary to consider a few limitations that are associated with research. To begin, carried out prospective observational research that lasted for two months and it was done at a single facility. This was research that was undertaken over a very short length of time owing to the limited money available to take away consecutive tip cultures of catheters.

Future Scope

In the future, it is crucial to explore the discharge of a comprehensive multimodal involvement aimed at lowering the occurrence of PICF among adult inpatients. This intervention should encompass an assessment of adherence to clinical practice standards regarding the insertion and management of PICs.

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None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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