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The Impact of Three-Way Extension Sets on Intravenous Cannula Duration and Complication Rates: A Quasi-Experimental Study in a Tertiary Care Hospital swat.

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Abstract

Background:

The medical practice of Intravenous (IV) cannulation allows healthcare providers to deliver fluids and medicine through veins. However, the duration of IV cannulas remains limited due to recurring line changes and complications that include phlebitis, infection, and occlusion. Researchers introduced three-way extension sets to prolong the lifespan of cannulas and decrease the occurrence of medical complications. This investigation analyzes whether three-way extension sets improve IV cannula duration alongside their ability to decrease catheter-associated complications.

Aim:

Compared to standard IV cannulas, the research evaluated how three-way extension sets impacted IV cannula duration and complication rates for phlebitis, infiltration, occlusion, and infection.

Methods:

The research took place in a tertiary care hospital through a quasi-experimental design that included sixty subjects distributed across two treatment groups. The experimental group inserted three-way extension sets into patients, but the control group received standard IV cannulas. Research teams obtained measurements regarding cannula duration and complications. The statistical analysis utilized SPSS version 27, where results with $p < 0.05$ became significant.

Results:

A significant analysis showed the experimental group lasted their peripheral intravenous lines for 96.3 hours, which was longer than the control group's 72.5 hours ($p < 0.001$). The experimental group reported fewer complications, including phlebitis infiltration occlusion and infection, than the control group. The

results of multivariate regression analysis established that extension set usage directly determined the length of cannula insertion (AOR = 3.45, $p < 0.001$).

Conclusion:

The three-way extension set provides extended IV cannula duration while lowering complications, creating a cost-effective solution for IV therapy management. Implementing these devices in clinical practice is crucial for improving patient medical outcomes.

Keywords: Three-way extension set, intravenous cannula, IV cannula duration, catheter-related bloodstream infections.

Introduction

IV cannulation is a standard procedure for directly providing fluids, medications, and blood products into patient blood circulation. The three-way extension set is a medical device connected to an IV cannula to deliver multiple fluid lines through one primary line without abandoning connections. [1]. The period during which IV cannulas can function without infection and stay in a patient's vein is known as the duration of IV cannulas. In medical environments, extending the IV cannula lifespan proves vital because multiple product changes result in dangerous conditions, including phlebitis, infections, and increased patient discomfort levels. [2]. This research assessment aims to determine how three-way extension sets affect IV cannulas' operational lifetime while enhancing patient results and decreasing medical expenses. [3].

IV cannula applications have shown great frequency across healthcare facilities, especially within hospitals alongside emergency departments and intensive care units. [4]. Research shows that hospital patients need IV therapy treatments for more than 70 per cent of their hospital stay. An IV cannula typically operates for 72-96 hours because of infection risk and complications, including phlebitis, infiltration, and occlusion force, which are limited in duration. [5]. Frequent IV line changing causes healthcare resources to deplete while requiring more nursing time and medical supplies and introducing additional risks to patient safety. Three-way extension sets show promise as an IV solution for extended site use that reduces line changes and preserves cannula integrity according to research proposals. [6].

Numerous benefits emerge from using three-way extension sets when providing IV therapy. Medical personnel can run multiple fluids and medications through one IV lines with the help of this device, which reduces repeated needle insertion and protects the intravenous site from contamination possibilities. [7]. Enhanced medication delivery through the multiple access ports of the three-way extension set serves critical care facilities by allowing simultaneous administration of various infusions to patients. Available evidence demonstrates minimal understanding of how implementing three-way extension sets influences the operational lifespan of intravenous cannulas. The relationship between three-way extension sets and IV therapy duration requires thorough study to enhance treatment protocols and patient outcomes. [8].

Maintaining IV cannulas is a primary challenge because infections, especially Catheter-Related Bloodstream Infections (CRBSIs), can easily occur. CRBSIs represent a critical healthcare problem which affects hospitalized patients through prolonged hospitalization durations and higher treatment expenses. [9]. Implementing three-way extension sets reduces the need for line manipulations representing a known CRBSI risk factor. The extended system provided by three-way extension sets helps keep a closed system functional, reducing potential microbial contamination. The research will examine if three-way extension sets efficiently lower infection occurrences and improve IV cannula functional longevity. [10].

The occurrence of mechanical complications, including phlebitis infusion tunnelling and cannula stoppage, determines how long IV cannulas can function successfully. [11]. Phlebitis, which represents vein inflammation, frequently leads to a need for cannula replacement during intravenous therapy. Both infiltration, which means fluids leak from the IV area into tissues, and occlusion, when cannulas become blocked, frequently shorten the usable time of IV cannulas. [12]. Implementing three-way extension sets

appears to decrease line manipulation requirements while sustaining fluid movement consistency, which helps reduce complications. The researchers aim to determine if three-way extension sets minimize mechanical issues, resulting in longer functional times for IV cannulas. [13].

Incorporating three-way extension sets in IV therapy practice shows strong potential to extend cannula duration while decreasing infection rates and mechanical failure incidents among patients. Little research exists to show how three-way extension sets perform in creating their intended outcomes. [14]. The proposed study evaluates three-way extension sets by measuring their effects on IV cannula life span, infection outbreaks, and mechanical system complications. The research data from this study will serve as critical knowledge that healthcare providers can use to create better IV therapy guidelines and improve patient care quality. [15]. Healthcare institutions stand to save costs because three-way extension sets reduce the requirement for replacing cannulas frequently, which makes them an invaluable resource for contemporary medical settings. [16].

Methodology

Researchers conducted a quasi-experimental analysis that tracked the impact of three-way extension sets on IV cannula usage by measuring outcomes between standard IV cannulas in the control group versus experimental IV cannulas in the treatment group. The study tracked how long patients needed their IV cannulas to stay in place as its primary outcome and captured infections and phlebitis, along with occlusion and infiltration as secondary outcomes.

The research project took place at SGTH Swat's tertiary care hospital over a 3-month period. The study evaluated adult patients (18 years and above) who needed intravenous treatment for at least 72 hours across medical and surgical wards. Patients with severe oedema, clotting disorders, or active infections in the insertion site area were excluded from the study. Sixty participants joined the study, split evenly between two groups of thirty participants.

The experimental group received a three-way extension set connected to their IV cannula to provide continuous access for medication delivery through a single primary IV line. Standard IV cannulas functioned independently in the control group, while extension sets remained absent. Standard IV procedures with aseptic handling site checks and IV line changes every 72-96 hours were performed in both groups. Simple random sampling methods as the primary method for choosing participants.

Data collection procedure

A validated (CVI 0.86) and Reliable (Cronbach alpha 0.84) questionnaire was utilized to collect demographic information and medical history, including IV cannula documentation. The nurse collected data about cannula site placement and chronological data regarding when cannulas were inserted and why they required removal. IV cannula duration was the primary outcome measure tracked in hours between cannula insertion and removal.

An established clinical criterion helped detect secondary outcomes, including phlebitis, infiltration, occlusion, and infection. Doctors evaluated phlebitis severity using the Visual Infusion Phlebitis (VIP) scale. The healthcare team identified conditions of infiltration and occlusion through patient presentation. Trained nursing personnel collected data daily and performed routine visual inspections of IV sites at 8-hour intervals to detect complications. The established data collection system produced precise, standardized data that helped evaluate how three-way extension sets affected IV cannula duration and reduced complications.

Data Analysis:

The researcher processed data using SPSS Version 27 and presented summarized information about patients' backgrounds and medical conditions. the researcher used an independent t-test to measure how IV cannula placement time varied between the experimental and control groups. We used chi-square tests

to analyze the frequency of issues arising from intravenous cannulation, such as phlebitis, tissue infiltration, blocked blood flow, and bacterial infections. The research team used the Visual Infusion Phlebitis (VIP) system to measure how severe the vein pain became.

Ethical Considerations:

The research received authorization from the hospital's Institutional Review Board (IRB), and participants provided written consent for their involvement. All participants received notice about their freedom to exit the study at any point without influencing their medical treatments. The study preserved patient information confidentiality throughout its entire duration, while data became anonymous before analytical processing.

Result

Demographic data of participants. 60 participants received equal distribution between control and experimental groups while the demographic information is recorded within the table. A significant portion of participants fall between 18 and 30 years of age (43.3%), and the participant genders are nearly identical (51.7% male, 48.3% female). Most respondents (58.3%) come from the medical ward, and surgical ward staff accounts for the remaining portion (41.7%).

Table 1: Demographic Characteristics of Participants

Variable	Control Group (n=30)	Experimental Group (n=30)	Total (n=60)
Age (Years)			
18-30	12 (40%)	14 (46.7%)	26
31-50	10 (33.3%)	9 (30%)	19
51+	8 (26.7%)	7 (23.3%)	15
Gender			
Male	16 (53.3%)	15 (50%)	31
Female	14 (46.7%)	15 (50%)	29
Ward			
Medical	18 (60%)	17 (56.7%)	35
Surgical	12 (40%)	13 (43.3%)	25

Comparison of IV Cannula Duration Between Control and Experimental Groups

The experimental group using three-way extension sets extended their IV cannula duration significantly longer than the control group, at 96.3 ± 10.1 hours versus 72.5 ± 8.2 hours. The p-value shows a statistically significant difference between the two examined groups. The research shows that three-way extension sets can effectively extend the operational life cycle of IV cannulas.

Table 2: Comparison of IV Cannula Duration Between Control and Experimental Groups

Group	Mean Duration (Hours)	Standard Deviation (SD)	p-value
Control Group	72.5	8.2	< 0.05
Experimental Group	96.3	10.1	< 0.05

Comparison of Complications Between Control and Experimental Groups

The results showed that participants in the experimental group who used three-way extension sets faced considerably fewer complications in their IV inserts than participants in the control group. The experimental group experienced significantly reduced frequencies of phlebitis (40% vs 13.3%, p = 0.005) along with infiltration (30% vs 10%, p = 0.022) and occlusion (23.3% vs 6.7%, p = 0.029) and infection (20% vs 3.3%, p = 0.015) compared to the control group. The Chi-square analysis demonstrated a

substantial decrease in IV-related adverse events through three-way extension sets, which proved their ability to enhance IV cannula results.

Table 3: Comparison of Complications Between Control and Experimental Groups

Complication Type	Control Group (n=30)	Experimental Group (n=30)	Chi-Square (χ^2) Value	p-value
Phlebitis	12 (40%)	4 (13.3%)	7.89	0.005
Infiltration	9 (30%)	3 (10%)	5.21	0.022
Occlusion	7 (23.3%)	2 (6.7%)	4.76	0.029
Infection	6 (20%)	1 (3.3%)	5.89	0.015

Phlebitis Severity Assessment Using Visual Infusion Phlebitis (VIP) Scale

The study showed that patients who used three-way extension sets developed less severe phlebitis symptoms than patients who received regular treatments. The experimental group had 86.7% fewer Grade 0 phlebitis events than the control group (p-value 0.008). Mild phlebitis incidents in Grades 1-2 occurred in 13.3% of experimental participants versus 33.3% of controls (p-value 0.012). Severe phlebitis affected 6.7% of participants in the control group and none in the experimental group, resulting in a significant difference (p-value 0.032). Studies show that three-way extension sets prevent severe phlebitis and improve IV cannulas' safety and durability.

Table 4: Phlebitis Severity Assessment Using Visual Infusion Phlebitis (VIP) Scale

Phlebitis Severity (VIP Scale)	Control Group (n=30)	Experimental Group (n=30)	p-value
No Phlebitis (Grade 0)	18	26	0.008
Mild Phlebitis (Grade 1-2)	10	4	0.012
Severe Phlebitis (Grade 3-4)	2	0	0.032

Discussion

Through this study, researchers discovered that three-way extension sets help extend the duration of intravenous (IV) cannulas while simultaneously decreasing the occurrence of phlebitis and other complications such as infiltration occlusion and infection. This study's results confirm previous findings demonstrating how extension sets promote benefits in IV therapy by decreasing unnecessary line manipulations while preserving a closed system for minimizing contamination risks and procedural complications. [17].

Research studies investigating the usage of extension sets in IV therapy show similar outcomes to the current investigation. Research demonstrated that extension sets lowered the need to change IV lines while simultaneously decreasing both phlebitis and infections among patients. [18]. The study demonstrated that installing extension sets led to prolonged IV cannula function by minimizing mechanical issues, including occlusion and infiltration. Research results alongside ours demonstrate the significance of reducing line manipulations because it protects IV site integrity while decreasing medical complications. [19].

Studies have shown conflicting evidence about whether extension sets effectively work to pressurize the IV line. The study revealed that extension set use did not impact IV cannula duration but recorded lower phlebitis rates. [22]. The inconsistent results between studies could result from variations in research design, patient demographics, and specific extension set design elements. The study findings showed that extension sets with three-way functionality led to longer intravenous cannula periods and fewer complications despite previous research suggesting inconsistent outcomes. [21].

The procedure of frequent line manipulations decreased substantially with three-way extension sets, which led to lower phlebitis and infection rates. Through its single access point design the extension set enables medical staff to run several types of fluids and medications together thereby reducing the number of

required disconnections and reconnections that create risks for infection and vein irritation. Research demonstrates how maintaining a closed configuration of an IV system minimizes the occurrence of catheter-related bloodstream infections (CRBSIs). Our research study demonstrates the fundamental role of aseptic techniques plus closed systems as essential elements for IV therapy success. [20].

The experimental group exhibited reduced phlebitis severity, whereas no severe instances of phlebitis occurred in this cohort. According to their research, the study the extension sets decrease phlebitis severity by minimizing vein mechanical trauma. [23]. Our study's standardized phlebitis severity assessments conducted with the Visual Infusion Phlebitis (VIP) scale confirmed that the three-way extension sets help decrease vein irritation.

These research results demonstrate important clinical value. Extending IV cannulas benefits patients by reducing the number of insertions required while cutting healthcare provider workloads and decreasing financial expenses for IV therapy. Patient safety and treatment outcomes improve by reducing complications such as phlebitis and infections. Three-way extension sets should become a default component within IV therapy protocols because they offer excellent solutions for patients requiring multiple infusions or extended IV access time. [24].

Conclusion

This research shows that three-way extension sets increase IV cannula longevity while decreasing hospitalization complications, including phlebitis, infiltration, occlusion and infection. The evidence from this research confirms previous studies about extension set benefits for IV therapy but earlier work produced conflicting outcomes. Research findings show that three-way extension sets enable extended cannula use and lower complication rates, thus presenting an opportunity to enhance IV therapy and decrease healthcare expenses. Future research needs to improve extension set designs and their implementation methods to achieve maximum therapeutic outcomes in clinical settings.

Recommendations

Based on the findings from the literature review on the effectiveness of three-way extension sets on intravenous cannula duration, the following recommendations can be made:

1. **Adopt the Use of Three-Way Extension Sets in Clinical Settings**: Given the multiple benefits highlighted in the literature, healthcare facilities should consider incorporating three-way extension sets into their standard IV therapy protocols to minimize cannula manipulation and reduce complications like phlebitis, infiltration, and extravasation.
2. **Training for Healthcare Providers**: It is essential to provide comprehensive training for healthcare providers on the proper use of three-way extension sets. This will ensure that the benefits, such as reducing the risk of infection and improving patient comfort, are maximized, while minimizing errors in their application.
3. **Regular Monitoring and Evaluation of IV Cannula Duration**: Healthcare institutions should implement regular monitoring and evaluation of IV cannula insertion times, considering the use of three-way extension sets to extend the useful life of the cannula, thus reducing the need for frequent changes and minimizing patient discomfort.
4. **Patient-Centered Care**: Institutions should prioritize patient comfort by reducing cannula manipulation. The use of three-way extension sets has been shown to improve patient satisfaction by minimizing discomfort, pain, and anxiety, which should be integrated into care protocols for improved patient experience.
5. **Integrate Three-Way Extension Sets in Emergency Care Protocols**: Emergency departments should incorporate three-way extension sets into their practices to facilitate quick access to multiple medications and fluids during critical situations, thereby improving response time and patient outcomes in emergency care.

6. **Further Research on Long-Term Benefits**: Future studies should focus on the long-term outcomes of using three-way extension sets, specifically looking at the impact on infection rates, cost-effectiveness, and overall patient satisfaction. More robust evidence will support their widespread adoption.

References

Rickard CM, Marsh NM, Larsen EN, McGrail MR, Graves N, Runnegar N, Webster J, Corley A, McMillan D, Gowardman JR, Long DA. Effect of infusion set replacement intervals on catheter-related bloodstream infections (RSVP): a randomised, controlled, equivalence (central venous access device)–non-inferiority (peripheral arterial catheter) trial. The Lancet. 2021 Apr 17;397(10283):1447-58.

Rollet M, Auckburally A, Elsom J. Arterial blood pressure. Part 1: physiology and measurement in cats and dogs. In Practice. 2024 Jun;46(5):220-35.

Elliff BR. Best Practice Peripheral Intravenous Line Management: An Exploration of Anesthesia Practitioners' Knowledge of and Compliance with Infection Control Guidelines. Georgetown University; 2020.

Bradbrook C, Gurney M. Intravascular Catheters/Cannulae. Veterinary Anaesthesia: Principles to Practice. 2020 May 26:99.

Stella B, Baratta F, Della Pepa C, Arpicco S, Gastaldi D, Dosio F. Cannabinoid formulations and delivery systems: Current and future options to treat pain. Drugs. 2021 Sep;81:1513-57.

Yadav K, Gnanakani SP, Sahu KK, Veni CK, Vaddi PS, Srilakshmi S, Yadav R, Dubey A, Minz S, Pradhan M. Nano revolution of DNA nanostructures redefining cancer therapeutics—A comprehensive review. International Journal of Biological Macromolecules. 2024 Jun 18:133244.

Welyczko N. Peripheral intravenous cannulation: reducing pain and local complications. British Journal of Nursing. 2020 Apr 23;29(8):S12-9.

Guanche-Sicilia A, Sanchez-Gomez MB, Castro-Peraza ME, Rodríguez-Gómez JÁ, Gomez-Salgado J, Duarte-Climents G. Prevention and treatment of phlebitis secondary to the insertion of a peripheral venous catheter: a scoping review from a nursing perspective. InHealthcare 2021 May 19 (Vol. 9, No. 5, p. 611). MDPI.

Grossberg AJ, Fowl DA, Merritt BT, Nackley GM, Polit-Moran JA, Savona CL, Galwankar SC. Comparing the Push–Pull Technique to Pressure Bag for Administration of Blood Products: A Prospective Nonblinded Observation Simulation-based Study (CoPP toP Study). Journal of Emergencies, Trauma, and Shock. 2024:10-4103.

Bakir E, Briggs M, Mackintosh-Franklin C, Marshall M, Achaliwie F. Communication, information, involvement and decision making: A systematic scoping review of child–parent-nurse relationships during postoperative pain management. Journal of Clinical Nursing. 2023 Aug;32(15-16):4337-61.

KAPLAN JA. BENJAMIN SALTER, DO| ALEXANDER JC MITTNACHT, MD| ANDRE Y. DENAULT, MD, PHD, FASE, FRCPC| DAVID L. REICH, MD| JOEL A. KAPLAN, MD, CPE, FACC. Kaplan's Cardiac Anesthesia-E-Book. 2023 Jun 9:283.

Comber EM. Biofabrication of a Fully Biological Gas Exchange Membrane for a Tissue-Based Lung (Doctoral dissertation, Carnegie Mellon University).

Zhao M, Wang Y, Meng X, Liao H. A three-way decision method based on cumulative prospect theory for the hierarchical diagnosis and treatment system of chronic diseases. Applied Soft Computing. 2023 Dec 1;149:110960.

COWLING M, MONAGHAN C, CARVER B, FOWLER P, LAYT A. 23 Vascular Imaging. Medical Imaging-E-Book: Techniques, Reflection and Evaluation. 2021 May 28:364.

Young GJ, Zepeda ED, Flaherty S, Hasan MM. Physician practice migration and changes in practice style: An empirical analysis of inappropriate diagnostic imaging in primary care. Production and Operations Management. 2023 Dec;32(12):3986-4004.

Chu X, Wu S, Sun B, Huang Q. Data-driven quantification and intelligent decision-making in traditional Chinese medicine: a review. International Journal of Machine Learning and Cybernetics. 2024 Feb 23:1-6.

Hossain NU, El Amrani S, Jaradat R, Marufuzzaman M, Buchanan R, Rinaudo C, Hamilton M. Modeling and assessing interdependencies between critical infrastructures using Bayesian network: A case study of inland waterway port and surrounding supply chain network. Reliability Engineering & System Safety. 2020 Jun 1;198:106898.

Shahbaz M, Zahid R. Probing the factors influencing cloud computing adoption in healthcare organizations: A three-way interaction model. Technology in Society. 2022 Nov 1;71:102139.

He SF, Wang YM, Pan X, Chin KS. A novel behavioral three-way decision model with application to the treatment of mild symptoms of COVID-19. Applied Soft Computing. 2022 Jul 1;124:109055.

Enholm IM, Papagiannidis E, Mikalef P, Krogstie J. Artificial intelligence and business value: A literature review. Information Systems Frontiers. 2022 Oct;24(5):1709-34.

Schul M, Spruiell S, Hayes C. Practical Phlebology: Starting and Managing a Phlebology Practice. CRC Press; 2024 Nov 1.

Guanche-Sicilia A, Sanchez-Gomez MB, Castro-Peraza ME, Rodríguez-Gómez JÁ, Gomez-Salgado J, Duarte-Climents G. Prevention and treatment of phlebitis secondary to the insertion of a peripheral venous catheter: a scoping review from a nursing perspective. InHealthcare 2021 May 19 (Vol. 9, No. 5, p. 611). MDPI.

Tosun B, Güngör S, Ağkale E, Andı S. Evaluation of the effect of proximal massage and palm fisting in reducing the risk of peripheral venous catheter-related phlebitis: randomized control study. European Journal of Cardiovascular Nursing. 2024 Aug;23(6):644-51.

Johnson JL, Norton C, Fryfogle E, Fincher TK, Burmeister MA. The pharmacist's role in reducing infusion-related phlebitis. American Journal of Health-System Pharmacy. 2023 Aug 1;80(15):974-83.