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DOCTORAL THESIS

Hierarchization of Failures in Peripheral Venous Catheter Insertion (CVP), from the Dual Perspective of the Performing Nurse and the Involved Patient"

SUMMARY

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Abbreviation	Description
ATI	Anesthesia and Intensive Care
AUD	Australian Dollar
CCV	Cardiovascular Surgery
CI	Interventional Cardiology
CAC	Central Arterial Catheter
CVC	Central Venous Catheter
CAP	Peripheral Arterial Catheter
CM	Medical Cardiology
CRBSI	Catheter-Related Bloodstream Infection
CVP	Peripheral Venous Catheter
CVP18G	Peripheral Venous Catheter 18G
CVP20G	Peripheral Venous Catheter 20G
CVP22G	Peripheral Venous Catheter 22G
CVR	Catheter-to-Vein Ratio
DZ	Diabetes Mellitus
DIVA	Difficult Intravenous Access
FE	Ejection Fraction
FAV	Arteriovenous Fistula
FEP	Radiopaque Catheter
HR	Hazard Ratio
IAAM	Healthcare-Associated Infection
IC	Confidence Interval
ICC	Congestive Heart Failure
IN	Infusion Nurses Society
IV	Intravenous
NRS	Numeric Rating Scale
OMS	World Health Organization
P	p-value
PTFE	Polytetrafluoroethylene
RR	Risk Ratio
SAU	Adjusted Odds Ratio
SM	Secondary Education
SS	Higher Education
TEF	Teflon Tubes
USD	US Dollar
VAS	Visual Analog Scale
VRS	Verbal Rating Scale
$\chi 2$	Chi-Square

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Respectfully,

Adriana Magdalena Dulbabă (ERZSE)

Short Summary

Hierarchizing the Failures of Peripheral Venous Catheter (PVC) Insertion from the Dual Perspectives of the Performing Nurse and the Involved Patient

The insertion of a peripheral venous catheter (PVC) is the most widely used minimally invasive procedure globally, with a failure rate ranging from 26% to 69%. Due to these considerations, this technique and the problems it entails during installation, maintenance, and removal were approached from multiple angles:

1. **Observation of Omissions**:

Conducted direct observations "without" and "with" prior notification of 79 performing nurses involved in PVC insertion, monitored through a checklist developed in the first study.

2. **Definition, Identification, and Classification of Failures:**

Failures were recorded and analyzed based on the timing of PVC insertion, the accessed vein, catheter size, educational level, and the experience of the nurses.

3. **Statistical Validation:**

Using the Epiinfo STATCALC module, we statistically validated results obtained from correlating independent variables (accessed vein, catheter size, educational level, and experience of performing nurses) with dependent variables (the 11 identified types of failures).

4. **Patient Perspective and Experience:**

Evaluated how patients perceive and experience the PVC insertion technique using the Visual Analog Scale (VAS) for pain, with results statistically validated through Epiinfo STATCALC.

Study 1:

In the first study, we monitored PVC insertion techniques against a checklist at different stages. Initially, without notifying the performing nurse, we recorded 927 omissions. In a subsequent phase, with prior notification, omissions decreased to 386.

Observations:

Nurses were observed during the three essential stages of PVC insertion: installation, care/manipulation, and removal. Observations were conducted in two separate phases: the first without prior notification, followed by feedback, and a second phase to assess improvements.

Results:

Significant reduction in omissions was observed across all stages after feedback. The overall omission rate dropped from 48.89% in the first phase to 20.35% in the second phase. Specifically, the installation stage saw the most significant reduction in omissions, from 55.50% to 17.81%, followed by the removal stage, from 44.05% to 22.53%, and the care and manipulation stage, from 38.61% to 24.05%.

Study 2:

Conducted on a cohort of 369 patients, we recorded 201 PVC insertion failures (PVC1), with 42 of these patients experiencing a second failure (PVC2).

Failure Analysis:after defining the 11 types of failures and distributing them across the three PVC insertion stages, the following were observed:

Failure by Vein Accessed: the highest failure rates were recorded for the median vein—37.31% for PVC1 and 52.38% for PVC2.
Failure by Catheter Size: the highest failure rates for PVC1 were with 18G catheters at 57.21%, and for PVC2 at 59.52%.
Failure by Nurse Experience: nurses with 0-1 year of experience had a failure rate of 49.75%, those with 1-5 years of experience had a failure rate of 25.87%, and those with over 5 years had a rate of 24.37%.

Study 3

Following statistical analysis using the Epiinfo STAT CALC2 program, we validated the following as risk factors:
For Time 1 (PVC Insertion): catheter size CVP18G with an associated relative risk (RR) of 1.8072.
For Time 2 (PVC Manipulation and Maintenance): median vein, CVP22G, and catheter operation duration greater than 25 hours for dislocation.
For Time 3 (PVC Removal): median vein, and catheter operation duration greater than 25 hours for accidental removal.
Analysis of independent variables such as patient age, gender, and presence of comorbidities (diabetes, obesity with BMI > 30) showed no statistical significance, as indicated by a Chi-square ($\chi 2$) test value less than 3.81 and a p-value greater than 0.05.

Study 4:

Using Epiinfo to analyze the association between independent variables (age, catheter size, gender, educational level) and dependent variables (the 6 pain scores according to the VAS scale), we identified the following risk factors:

- Mild pain: Individuals over 65 and those aged 46-65 with minimal education.
- Moderate pain: Individuals aged 16-45 and 46-65.
- Severe pain: Individuals aged 46-65 using CVP18G.
- Very severe pain: Individuals with a bachelor's degree.
- Unbearable pain: Individuals aged 46-65 with a college degree.

The first study in this thesis demonstrates the importance of continuous medical education, which should be conducted not in a formal, theoretical manner but with a pronounced practical aspect tailored to each group of nurses working in a specific department, hospital, or clinic, using a checklist as a working tool for each procedure performed.
Studies 2 and 3 identify the failures during work times and rank the risk and protection factors.
In Study 4, the hospitalized patients' opinions and pain tolerance perception according to the VAS scale draw attention to the more intense experiences of those over 65 with higher education and a large 18G catheter inserted, indicating that performing nurses should pay more careful attention to this category of patients.

General Part

1.1. Introduction

In current practice, the use of peripheral venous catheters (PVCs) plays a very important role in patient care, a fact recognized by Zimmermann, Meyers, and Massa 70 years ago when the first such plastic devices were used in humans (Helm et al., 2015; Zerati et al., 2017). Absolutely necessary for the administration of fluids and medications into the bloodstream, the placement of catheters in the peripheral venous circuit is still recognized today as the most common minimally invasive procedure performed in hospitals worldwide.

The peripheral venous catheter is considered a critical medical device because it involves direct contact and penetration of the tissues of the human body. It is mandatory that these devices are sterile at the time of their use (B. Braun Medical, 2022). The process of inserting a catheter is called "catheterization." Correct use of peripheral venous catheters is essential to minimize the risk of device failure and the occurrence of other associated complications (Diggery, 2012).
It has been noted that more than 300 million peripheral intravenous catheters are sold each year in the United States, and between 60% and 90% of hospitalized patients require such a catheter throughout their hospital stay (Soifer, 1998; Helm et al., 2015). The peripheral venous catheter, also known as a cannula or intravenous cannula, maintains venous access for a period of 72-96 hours, only if inserted and cared for properly.

Peripheral venous catheter (PVC) failure is defined as the removal of the catheter for any reason other than exceeding the maximum dwell time or completing intravenous treatment, and it is considered a complication. Most complications are non-infectious. Helm et al. (2015) emphasized the need to raise awareness that these failures are a relevant problem that must be reduced by improving current PVC insertion practices. Although PVC insertion is a routine procedure, studies in the specialized literature note an inconsistency between theory and current practice (Alexandrou et al., 2018; Gorski et al., 2021). These findings certainly contribute to the high incidence of complications related to PVC, with overall failure rates ranging from 26% to 69% (Zingg et al., 2023; Marsh et al., 2020; Lim et al., 2019).
Among the complications recorded as PVC insertion failures, we list:

- Phlebitis, evaluated using the phlebitis scale according to the Infusion Nurses Society (INS) (Gorski et al., 2021).
- Infiltration/extravasation—leakage of the administered fluid with an irritating effect from the cannulated blood vessels into the surrounding tissues (Hadaway, 2007).
- Occlusion—the inability to administer the infusion treatment (Chen et al., 2022).
- Displacement—accidental removal or movement of the device leading to loss of function (Helm et al., 2015).

Mermel (2017) and Webster (2019) studied the incidence and prevalence of complications related to PVCs, regarding the impact of catheter replacement according to guidelines or clinical indication. The research was conducted in various medical units, including intensive care units, intermediate care units, and oncology units, and supports that PVC replacement based on clinical reasons or at regular intervals can be as effective as routine replacement every 96 hours (Vendramim et al., 2020).

Relevant Bibliographical Sources

Relevant bibliographical sources highlight the importance of preventing peripheral venous catheter (PVC) insertion failures by avoiding certain omissions:

- Blanco-Mavillard et al. (2021) emphasize that neglecting proper hygiene during the insertion or maintenance of PVCs can increase the risk of contamination and infections. Additionally, delaying or improperly removing the catheter can elevate the risk of serious complications.
- The Australian Commission on Safety and Quality in Health Care (2021) highlights that incorrect insertion techniques can lead to inadequate positioning or venous perforation, compromising the proper functioning of the catheter.
- European Recommendations for the Indication and Proper Use of Peripheral Venous Access (2021) warn against improper maintenance and the potential for thrombus formation or bacterial contamination.

PVC introduction is challenging for some patients, leading to delays in care and workflow. Identifiable risk factors can distinguish difficult intravenous access (DIVA) patients from compliant ones.In a prospective observational study, adults at high risk for difficult peripheral intravenous cannulation (DIVA) were included after identification based on three simple criteria: absence of a visible vein, absence of a palpable vein, or a history of DIVA (difficulty in intravenous PVC insertion) (Sweeny et al., 2021).

The study revealed that first-attempt success was less likely in high-risk DIVA patients (61.1% vs. 85.0%, $p < 0.001$), with a higher probability of requiring multiple attempts, ultrasound guidance, and smaller gauge PVC placement in the wrist or hand.

The study results suggested that early identification of high-risk DIVA patients and escalation to experienced personnel or the use of ultrasound as an adjunct could help avoid unnecessary attempts and delays in PVC insertion (Sweeny et al., 2021).

In particular situations, using ultrasound can be highly beneficial in identifying suitable veins, especially when they are not visible or palpable. Identifying and evaluating various strategies and techniques used to prevent and manage PVC insertion failures, such as appropriate practical training and improved puncture techniques, interprofessional collaboration, continuous education for nurses, and counseling in managing patients' emotional reactions, can improve success rates and patient satisfaction.

By approaching each PVC insertion procedure comprehensively and empathetically, technical success can be ensured, along with patient comfort and satisfaction, which are essential for the quality of medical care.

Personal Contributions

2.1. Studies and General Objectives

In this research, I aimed to find practical solutions to improve the management of peripheral venous catheter (PVC) insertion procedures by observing the direct execution of the technique by nurses, defining failures, ranking risk and protective factors, and monitoring the pain tolerance of patients with PVC. To achieve this goal, I formulated several objectives, which are addressed through four distinct studies, each focusing on different aspects of the issue and detailed in Figure 1.

The main objectives of the research include:

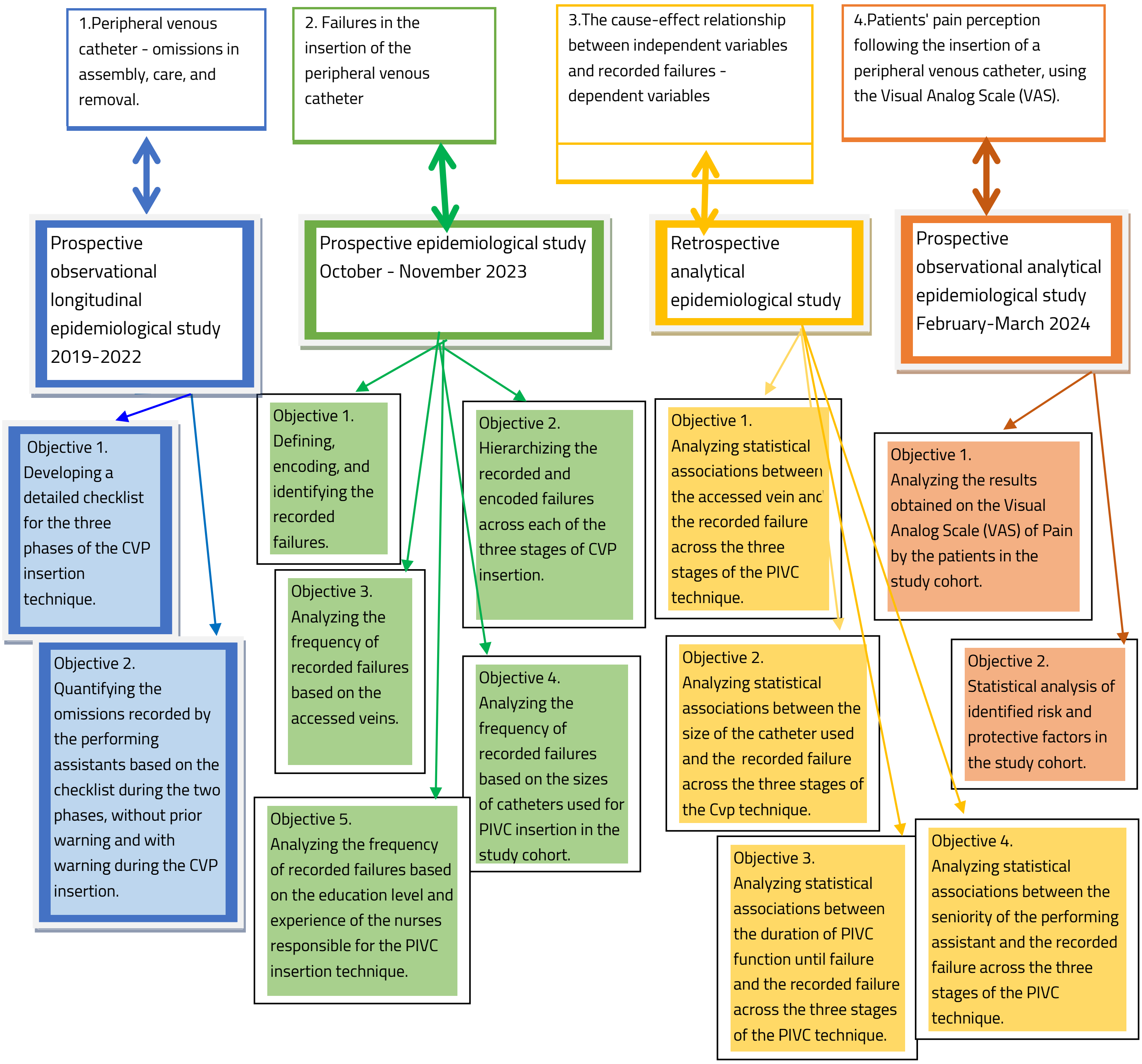

Figure 1. The four research studies with their corresponding objectives.

Study 1

Peripheral Venous Catheter - Omissions in Insertion, Care, and Removal

3.1. Introduction

Throughout my research, I have noticed that the technique of peripheral venous catheter (PVC) insertion, in all its complexity, is not the responsibility of a single nurse but involves multiple practitioners depending on the duration of the device's use. My observations regarding the execution of the PVC insertion technique include:

- Stage 1: Insertion is the responsibility of a single executing nurse.
- Stage 2: Maintenance and Handling involves the intervention and responsibility of multiple executing nurses.
- Stage 3: Removal of the catheter is managed by a single executing nurse, who is also responsible for concluding the PVC insertion technique.

3.2. Purpose

The purpose is to evaluate in detail the execution of the PVC insertion technique by executing nurses, based on the three stages of work: insertion, maintenance/handling, and removal of the device, in order to identify possible omissions in the procedure.

3.3. Objectives

1. Develop a detailed checklist for the three stages of the PVC insertion technique.
2. Quantify the omissions recorded by executing nurses based on the checklist during the two phases: without prior notification and with notification during PVC insertion.

3.4. Materials and Methods

This was a prospective epidemiological, observational, longitudinal study conducted from January 2019 to January 2022 at a private Cardiology Hospital in Brasov. The study was conducted based on a checklist developed during my research, through which I systematically monitored and noted the omissions recorded during the three stages of the PVC insertion technique.

In addition to the detailed checklist, 79 executing nurses of the PVC insertion technique were involved in this research. I monitored their technique and quantified the omissions in two distinct phases of the study: the first phase without prior notification to the nurse and the second phase with prior notification, ensuring the accuracy of the PVC insertion technique.

3.5. Results and Discussions

In this study, according to the PVC insertion technique checklist, I monitored 24 items distributed across the three stages of work: 13 items during Stage 1 (insertion), 6 items during Stage 2 (maintenance and handling of the device), and 5 items for Stage 3 (removal), totaling 3,792 items monitored through the 79 executing nurses over the two observation phases.

During the first phase of observation without prior notification to the executing nurse, we recorded 927 omissions out of 1,896 items. In the second phase with prior notification, there were 386 omissions out of the same total items. The results obtained highlighted a significant reduction in omissions across all three stages of PVC insertion.

In the second phase after prior notification to the executing nurse, the overall omission rate decreased from 48.89% in the first phase to 20.35%.
We present a comparative analysis of the omissions recorded in the two work phases, detailing each item from the checklist corresponding to the three stages of the PVC insertion technique.

Table 1: Prevalence Differences between the 2 Observation Phases for Stage 1 - PVC Insertion

	Time 1 Insertion of the Peripheral Venous Catheter	Stage 1 without alerting	Stage 2 with alerting	prevalence difference
1.	Presentation of the assistant	49.37%	3.80%	45.57%
2.	Patient identification	15.19%	0%	15.19%
3.	Psychological preparation of the patient	49.37%	3.80%	45.57%
4.	CVP insertion - delegated task	68.35%	7.59%	60.76%
5.	Verification and preparation of materials	68.35%	7.59%	60.76%
6.	Hand hygiene	49.37%	26.58%	22.79%
7.	Assessment of the venous bed and identification of the puncture site	45.57%	15.19%	30.38%
8.	Correct disinfection of the skin	49.37%	22.78%	26.59%
9.	Aseptic dressing application	75.95%	37.97%	37.98%
10.	Catheter flushing	41.77%	15.19%	26.58%
11.	Patient education for monitoring and caring for the CVP	87.34%	37.97%	49.37%
12.	Noting the time and initials of the assistant on the dressing	60.76%	26.58%	34.18%
13.	Documentation of CVP insertion in the care plan	60.76%	26.58%	34.18%

During time 1 of CVP insertion, the greatest reduction in omissions was recorded, from 55.50% to 17.81%.

Table no. 2

Difference in prevalences between the 2 stages of observation during Time 2 - maintenance and monitoring

Nr. crt.	Time 2 Care and handling	Stage 1 without alerting	Stage 2 with alerting	prevalence difference
1	Daily assessment of CVP patency	37.97%	26.58%	11.39%
2	Recording the phlebitis score	34.18%	22.78%	11.40%
3	Periodic washing of the CVP	37.97%	26.58%	11.39%
4	Daily dressing of the deteriorated CVP	41.77%	18.99%	22.78%
5	Disinfection of the administration ports	60.76%	34.18%	26.58%
6	Changing the CVP based on the degree of phlebitis	18.99%	15.19%	3.80%
Total	474	183	114	

In time 2, during care and handling of the CVP, the smallest reduction in omissions was recorded, from 38.61% to 24.05%.

Table no. 3 Difference in prevalence between the 2 stages of observation for time 3 - removal of CVP

Nr. crt.	Time 3 Suprimarea CVP	Stage 1 without alerting	Stage 2 with alerting	prevalence difference
1	Removal as per physician's indication	11.39%	3.80%	7.59%
2	Adherence to aseptic and antiseptic rules during removal	49.37%	22.78%	26.59%
3	Documenting the date and time in the Care Plan	56.96%	34.18%	22.78%
4	Sending to the laboratory for microbiological tests	2.53%	2.53%	0.00%
5	Patient education after removal of the CVP	100.00%	49.37%	50.63%

In time 3, during the removal of the CVP, there was a moderate decrease in omissions from 44.05% to 22.53%.

The 28.54% difference in CVP insertion technique compliance represents a reduction of 541 omissions. The results indicate a significant improvement in CVP insertion technique compliance after discussing and pre-warning the effector assistants in stage 2. This signifies a substantial reduction in insertion technique omissions, from an initial 927 to 386 omissions after the warning. Studies referenced in the consulted literature underline the importance of continuous education and periodic retraining to enhance medical assistants' practices (Cicolini et al., 2014; Simonetti et al., 2019).

3.6. Conclusions:

1. The research identified omissions and inefficiencies in the current techniques of CVP insertion across the three stages (placement, care, and removal).
2. Critical moments were identified within each of the three stages of the technique using a detailed checklist.
3. The research findings can serve as a basis for updating current clinical guidelines and developing continuous training programs for medical assistants.

Study 2

4. Failures in Peripheral Venous Catheter Insertion: A Prospective Epidemiological Study

4.1. Introduction

Failure in peripheral venous catheter (CVP) insertion techniques can significantly impact medical quality and may increase hospitalization duration and associated costs. Specialized literature indicates a considerable failure rate, ranging from 26% to 69%. Various new techniques and technologies have been implemented to reduce these significant failure rates, such as ultrasound-guided vein localization, improved catheters with protective accessories, and antibiotic-impregnated dressings.

4.2. Purpose

To identify failures in peripheral venous catheter (CVP) insertion techniques across the three stages: insertion, care/handling, and removal of the CVP.

4.3. Study Objectives

1. Define, code, and identify failures in CVP insertion techniques.
2. Prioritize the failures recorded across the three stages of CVP insertion.
3. Analyze the frequency of failures recorded based on the accessed veins for CVP insertion.
4. Analyze the frequency of failures recorded based on the sizes of catheters used for CVP insertion.
5. Analyze the frequency of failures recorded based on the experience and tenure of the medical assistants involved in CVP insertion. 4.4. Materials and Methods An epidemiological, prospective, observational study was conducted at a cardiology hospital in Brasov over a period of 60 days. It included 369 adult patients who received indications for CVP insertion. Data were collected through continuous monitoring of inserted catheters by medical assistants during their shifts, throughout their functioning from insertion to failure detection

or indicated removal. Monitoring of failures was conducted by aggregating entries from patient care plans, an integral part of general clinical observation sheets, and handover records where medical assistants noted details such as insertion date, associated adverse events until failure, and the measures taken. 4.5. Results Out of 369 patients, 201 (54.47%) experienced a failure during CVP insertion. Eleven failure codes were identified, named, and coded in the CVP insertion technique.

Time 1 CVP insertion identified 2 codes: Code 01 - unsuccessful puncture, Code 02 - venous perforation.
Time 2 CVP handling and maintenance identified 5 codes: Code 03 - incorrect dislocation and fixation, Code 04 - inflammation/phlebitis, Code 05 - infiltration/extravasation, Code 06 - occlusion/blockage, Code 07 - infection.
Time 3 CVP removal identified 4 codes: Code 08 - accidental removal, Code 09 - discomfort/requested removal, Code 10 - pain/requested removal, Code 11 - voluntary removal.

Failures in CVP insertion, by work stages of the technique:
Time 1 (CVP insertion): The main causes of failure were unsuccessful puncture 56.16% and venous perforation 43.83% of the total CVP insertion failures during this work stage.
Time 2 (CVP handling and maintenance): Dislocation 40.25% and infiltration 27.27% were most frequent among the total CVP insertion failures during this work stage.
Time 3 (CVP removal): Pain 47.05% and accidental removal 39.24% were most frequently observed among the total CVP insertion failures during this work stage.

Failures in CVP insertion, by accessed veins:
Time 1 (CVP insertion): Failure rate was 38.35% on the median vein, 32.87% on the cephalic vein, lower failure rates were observed on the dorsal veins (20.54%) and basilic vein (8.21%).
Time 2 (CVP handling and maintenance): Failure rate was 40.25% on the median vein, 29.87% on the cephalic vein, the basilic vein showed an increase in failure rate compared to Time 1, reaching 16.88%, and 12.97% were observed on the dorsal veins.
Time 3 (CVP removal): High failure rates of 31.37% and 29.41% corresponded to the median vein and cephalic vein, dorsal veins showed a significant increase in failure rate during this time, reaching 27.45%, while the basilic vein recorded 11.76%.

Failures in CVP insertion, by catheter size:
Time 1 (CVP insertion): -71.23%, CVP18G had the highest failure percentage, indicating difficulties in puncture and initial catheter insertion. The green-coded CVP18G catheter, with an inner diameter of 0.9mm and outer diameter of 1.3mm, length 45mm, is recommended for major medical procedures in adults.
Time 2 (CVP handling and maintenance): -45.45%, both CVP18G and CVP22G were involved in significant failures, either due to dislocation (CVP22G) or issues like infiltration and occlusion (CVP18G). The blue-coded CVP22G catheter, with an inner diameter of 0.6mm and outer diameter of 1.1mm, length 25mm, is preferred for thin and fragile veins, particularly in elderly and pediatric patients.

Time 3 (CVP removal): -54.90%, CVP20G presented significant failure rates during this time, including patient discomfort leading to catheter extraction. The pink-coded CVP20G catheter, with an inner diameter of 0.8mm and outer diameter of 1.1mm, length 32mm, is recommended for infusions and parenteral medication administration in adults.
It is evident that larger catheter sizes may contribute to difficulties in puncture, handling, and patient comfort.

Failures in CVP insertion, by education level (SS/SM) and experience:
Time 1 (CVP insertion): Middle education level (SM) assistants recorded a failure rate of 56.16% compared to higher education level (SS) assistants at 43.84%. Novice assistants (0-1 year experience) had the highest failure rate at 49.75%.
Time 2 (CVP handling and maintenance): Middle education level (SM) assistants recorded a failure rate of 58.44% compared to higher education level (SS) assistants at 41.56%. Moderately experienced assistants (1-5 years) had a failure rate of 25.87%.
Time 3 (CVP removal): Middle education level (SM) assistants recorded a failure rate of 64.70% compared to higher education level (SS) assistants at 35.30%. Highly experienced assistants (over 5 years) recorded the lowest failure percentage at 24.37%.

4.6. Conclusions

1. The didactic detailing of the CVP insertion technique, as outlined in Thesis Study I, was utilized in the present study to support the categorization of failures defined by us across work stages, a hierarchy not documented in the consulted literature but considered highly relevant in current practice. The study emphasizes the importance of a systematic approach in identifying and managing CVP insertion failures within the recorded timeframes.
2. Defining failures and numerically coding them from 1-11 clarified their categorization within work stages, enabling healthcare providers to better understand the specific types of failures they may encounter during the monitoring of inserted CVPs.
3. The distribution of failures across the four types of veins accessed for peripheral venous catheter insertion is as follows: the median vein records the highest failure percentage of 37.31%, followed by the cephalic vein at 30.84%, dorsal veins at 19.40%, and basilic vein at 12.43%.
4. The distribution of failures based on catheter sizes 18G, 20G, 22G for CVP shows that CVP18G has the highest percentage at 57.21%, followed by CVP20G and CVP22G each at 22.39%.
5. The failure rate, evaluated based on the professional education of healthcare providers, shows the highest percentage among personnel with middle education levels (graduates of secondary medical schools and post-secondary schools) across all CVP insertion stages. According to the data, the failure percentages are as follows in descending order: 64.70% for time 3, 58.44% for time 2, and 56.16% for time 1.
6. Healthcare providers with 0-1 years of experience (beginners) have the highest insertion failure rates, evaluated at 49.75% compared to those with 1-5 years at 25.87% and over 5 years at 24.37%.

7. The optimal approach recommended for selecting veins for CVP insertion prioritizes the dorsal veins of the non-dominant arm, progressing towards the root of the arm. This condition was not consistently observed in current practice within the study cohort. The failure distribution in the study cohort based on accessed veins is: median vein - 37.31%, cephalic vein - 30.84%, dorsal veins - 19.40%, and basilic vein - 12.43%. The initial approach to the median vein in the cubital fossa recorded the highest percentage of insertion failures, along with the not negligible possibility of rapidly depleting available venous resources.

Discussions

In our study, out of the total 369 included patients, 54.51% experienced failures during the CVP insertion procedure. Chen YM, Fan XW, et al. (2022) - in a prospective cohort study conducted at nine tertiary hospitals in Suzhou, China, involving 5,345 patients, recorded a peripheral venous catheter insertion and maintenance failure rate of 54.05%, similar to our study results. Differences could be attributed to specific patient characteristics in each study, such as age and the prevalence of certain comorbidities. Novelty! In this study, we emphasized a didactic detailing of the technique precisely to categorize CVP insertion failures across the three work stages, a hierarchy not found in the consulted literature but crucial for follow-up and management in current practice. In this context, revising the CVP insertion technique procedure in accordance with the obtained results would be necessary, addressing each of the three stages individually with their corresponding failures. This is what I intend to achieve and expand upon in the hospital where I work, to evaluate the evolution of failure rates over time and communicate my findings in a specialized journal.

Study 3

The present study aims to statistically validate the failures in peripheral venous catheter (PVC) insertion as identified and analyzed in previous research, with the goal of improving the quality of care for the inserted device.

5.1. Introduction

Nicole M. and colleagues (2020) conducted a meta-analysis on 1000 patients at a tertiary hospital in Queensland, Australia, reporting a 32.44% failure rate of PVC insertion technique. The main identified risk factors were occlusion (HR, 1.98; 95% CI, 1.19-3.31), use of a 22-gauge catheter (HR, 1.43; 95% CI, 1.02-2.00), and female gender (HR, 1.48; 95% CI, 1.10-2.00).

Chen YM and colleagues (2022), along with Robert E. Helm (2015), investigated the failure rates of peripheral venous catheter insertion, highlighting phlebitis and infiltration/extravasation as primary dependent variables, with a 54.05% rate. They considered age, department, recent venipuncture history, insertion site, and number of puncture attempts as independent variables for PVC insertion failure. The logistic regression model based on these variables had moderate accuracy in predicting PVC failure (AUC = 0.781).

In a prospective observational cohort study, Abolfotouh MA and colleagues (2014) focused on investigating complications of peripheral venous catheters in 359 adult patients admitted to various departments of a hospital in Riyadh, Saudi Arabia. They evaluated complications and PVC insertion failures, reporting phlebitis (17.6%), pain (7.6%), infiltration (3.9%), displacement (2.4%), and occlusion (0.5%) as the main complications, using SPSS statistical software and considering P-values < 0.05 as significant.

Following the example set by the literature, we aimed to examine to what extent the results of Study 2 from this Doctoral Thesis can be statistically validated. We analyze the cause-effect relationship between independent variables - accessed vein, catheter size, healthcare providers' educational level and work experience - and dependent variables - the failure codes recorded during device maintenance.

5.2. To assess the association between independent variables: veins accessed for CVP insertion, catheter sizes, duration of catheter function, healthcare providers' educational level and work experience, and dependent variables: the failure codes recorded during device maintenance.

5.3. Objectives

1. Analyze statistical associations between the punctured vein and the failure code recorded during CVP insertion, maintenance, and removal.
2. Analyze statistical associations between the catheter size used and the failure code recorded during CVP insertion, maintenance, and removal.
3. Analyze statistical associations between the duration of CVP function until failure and the failure code recorded during insertion, maintenance, and removal.
4. Analyze statistical associations between healthcare providers' work experience and the failure code recorded during insertion, maintenance, and removal of CVP.

5.4. Materials and Methods

To achieve the research objectives, we utilized EpiInfo software, specifically the STAT CALC module, to conduct detailed statistical analysis to identify the cause-effect relationship between independent and dependent variables associated with failures in peripheral venous catheter insertion. From the STAT CALC module, we employed 2x2 contingency tables to input our collected data and perform the chi-square test to determine if there is a significant association between the variables analyzed within the proposed hypothesis framework. We used a significance threshold for the test where a value > 3.81 and for $p < 0.05$ indicates a significant association. In this situation, when RR is > 1, it supports our hypothesis that the factor in question (vein, catheter size, and duration of catheter function) is recognized as a risk factor.

Conversely, when RR < 1, this finding suggests an association with protection against failure, thus confirming our hypothesis (Dean, et al., 2013).

Inclusion and exclusion criteria were established in accordance with our research objectives to ensure the coherence and relevance of the analyzed data.

5.5. Results and Discussions

Risk and Protective Factors Identified Across Three Stages of CVP Insertion

During Stage 1: Catheter Insertion

Code 01 - Paravenous/Failed Puncture

- CVP 18G is identified as a risk factor for code 01 - failed puncture (χ 2-3.8447, p-0.025472, RR-1.8072).
- CVP 22G is identified as a protective factor for the same code 01 - failed puncture (χ 2-6.0685, p-0.000493, RR-0.2901). Following evaluation of the patient's peripheral vascular

package, in situations where we anticipate a safe puncture cannot be achieved with an 18G catheter, it is advisable to initiate insertion with a 20G or 22G CVP, with the attending physician's consent, to reduce the risk of failed puncture.

During Stage 2: Manipulation and Maintenance of CVP

Code 03 - Failure due to Catheter Dislocation

- Median vein is a risk factor for code 03 - dislocation (χ 2-14.5088, p-0.000114, RR-3.5280).
- Basilic vein is a protective factor for the same code 03 - dislocation (χ 2-5.2064, p-0.005629, RR-0.000001). Therefore, when encountering situations where the risk of dislocation may be anticipated, it is recommended to initiate CVP insertion with the basilic vein as the primary access, thus benefiting from greater stability and functionality of the peripheral venous catheter. This approach can contribute to reducing the failure rate associated with catheter dislocations and may improve clinical outcomes for patients.
- CVP 22G is a risk factor for code 03 - dislocation (χ 2-85.0802, p-0.000001, RR-19.1070), while CVP sizes CVP 20G (χ 2-9.9752, p-0.000140, RR-0.00001) and CVP 18G (χ 2-25.2737, p-0.000002, RR-0.1438) are protective factors against dislocation.

Code 05 - Failure due to Infiltration/Extravasation

- Cephalic vein is a risk factor for code 05 - infiltration/extravasation of administered solutions (χ 2-10.6048, p-0.001140, RR-3.6431).
- Median vein is a protective factor for the same code 05 - infiltration/extravasation (χ 2-7.7423, p-0.001869, RR-0.1768). Anatomical location of the veins is crucial in selecting the access vein to prevent infiltration.
- CVP 20G is a risk factor for code 05 - infiltration/extravasation (χ 2-6.8320, p-0.002342, RR-0.0000). CVP 22G, being smaller in size, is a protective factor against code 05 - infiltration/extravasation (χ 2-10.6048, p-0.001140, RR-3.6431). In practice, the smaller diameter and length of CVP 22G may reduce pressure on the vascular wall and thereby decrease the risk of injury and extravasation of medicinal solutions.

During Stage 3: Removal of CVP

Code 08 - Failure due to Accidental Removal

- Healthcare providers with an average tenure of 1-5 years constitute risk factors for code 08 - accidental removal. Healthcare providers with tenure of 0-1 year are protective factors for code 08 - accidental removal. Practical experience suggests that novice healthcare providers are more attentive and cautious during procedures, closely monitoring them.

Code 09 - Failure due to Patient Discomfort

- Dorsal veins are risk factors for code 09 - discomfort leading to premature removal of the catheter (χ 2-30.1267, p-0.000003, RR-NEDEFINIT).
- Median vein is a protective factor for code 09 - discomfort leading to failure (χ 2-4.3170, p-0.017840, RR-0.0001). In current practice, dorsal veins, due to their superficial position and frequent exposure to daily activities, may be more susceptible to uncontrolled movements and trauma, resulting in a high level of discomfort prompting patient-requested catheter removal.

Code 10 - Failure due to Patient Pain

- Basilic vein is a risk factor for code 10 - pain experienced by the catheter-bearing patient (χ 2-3.9492, p-0.036320, RR-2.3467).
- Median vein is a protective factor for code 10 - pain experienced by the catheter-bearing patient (χ 2-7.1741, p-0.002867, RR-0.2400). Practical experience underscores the importance of anatomical vein location in ensuring safe insertion. These practical approaches could improve patient comfort and prolong catheter functionality.

Table 4. Identified Risk Factors versus Protective Factors

CVP18G-(01)-paravenous puncture	CVP 22G-(01)-paravenous puncture
-	CVP 22G-(03)-venous perforation
Median vein-(03)-displacement	Basilic vein-(03) displacement
CVP 22G-(03)-displacement CVP>25 hours-(03)-displacement	CVP20G -(03)-displacement CVP18G -(03)-displacement CVP <10 hours -(03)-displacement
Basilic vein CVP1-(4)-inflammation Median vein CVP2-(04)-inflammation CVP<10 hours-(04)-inflammation	- - -
Cephalic vein CVP1-(5)-infiltration CVP20G CVP1-(05)-infiltration CVP<10 hours CVP1-(05)-infiltration	Median vein - (05) infiltration CVP 22G-(05) infiltration -
Median vein CVP1-(08)-accidental removal CVP>25 hours CVP1-(08)-accidental removal Average-tenure assistants CVP1-(8)-accidental removal Cephalic vein CVP2-(08)-accidental removal CVP20G -E. CVP2-(08)-accidental removal	Median vein CVP2-(08) accidental removal CVP <10 hours CVP1 -(08) accidental removal Beginner assistants CVP1-(08) accidental removal CVP18G-E. CVP2-(08) accidental removal
Dorsal veins CVP1-(9)-discomfort during removal	Median vein CVP1-(9) discomfort during removal
Basilic vein CVP1-(10)-pain Assistants with over 5 years of tenure CVP1-(10)-pain	Median vein CVP1-(10) pain during removal -

Results obtained through statistical analysis using EpiInfo, STATCALC module, 2x2 contingency tables identified risk and protective factors associated with CVP insertion, highlighting the importance of proper assessment and management in the context of medical practice.

Table no. 5
Numerical distribution of risk factors and protective factors based on the independent variables analyzed in the study

Risk factors CVP1-15	Protective factors CVP1-12
3 - CVP size	5 - CVP size
6 - accessed veins	4 - accessed veins
4 - duration of CVP function until failure	2 - duration of CVP function until failure
	1 - assistant's tenure
Risk factors CVP2-3	Protective factors CVP2-2
1 - CVP size	1 - CVP size
2 - accessed veins	1 - accessed veins

5.6. Discussions

Miliani et al. (2017) - in a prospective observational study found that inserting CVPs in dorsal veins or wrist veins was not significantly associated with CVP complications (p = 0.10 and p = 0.94, respectively). However, insertion in the median cubital vein in the antecubital fossa recorded a risk of 1.72 (95% CI 1.14–2.59), which is consistent with our findings.

In the AMOR-VENUS study, Kashiura et al. (2022) found that 56.2% of peripheral venous catheters were inserted in the forearm, 21.3% in the hand, and 6.7% in the upper arm, without specifying the exact failure rates for each type of accessed vein.

Mostafa et al. (2014) found that patients with smaller catheter sizes (CVP 22G, CVP 24G) had a complication rate of 34.26%. Patients receiving smaller catheters were more likely to experience failures compared to those receiving larger sizes (G16, G18, G20). Patients with smaller catheters had approximately twice the chance of experiencing complications compared to those with larger catheters (RR = 1.84, 95% CI: 1.44–2.36, P = 0.000001). Their results are contradictory to our findings.

However, our results are in line with the failure rate proportions reported in the study by Shrestha et al. (2021) on 390 patients from a tertiary hospital, indicating complication rates of 57.70% for 18G catheters, 35.00% for 20G catheters, and 5.1% for 22G catheters.

5.7. Conclusion

1. The study provided a detailed and systematic analysis of risk and protective factors associated with failures in CVP insertion, highlighting the need for improved clinical practices and professional training in CVP management.
2. No significant correlations were identified between gender, age, obesity, diabetes, and the risk of CVP insertion failure for the 11 types of failures analyzed. These results suggest that other factors or variables may have a greater influence on the risk of CVP insertion failure, emphasizing the need for further research for a deeper understanding of these aspects.
3. The study represents an important contribution to the literature on peripheral venous catheter management, highlighting the complexity and necessity of a personalized approach to risk/protection factors associated with CVP insertion, which is a novel aspect in my research.
4. Our study demonstrates a statistically significant positive impact on the success of CVP insertion with a 22G catheter in the median vein and a maintenance duration under 25 hours as clinically indicated.

Study 4

6. Perception of Pain by Patients Following Peripheral Venous Catheter Insertion Using the Visual Analog Scale (VAS)

6.1. Introduction

Peripheral venous catheter (PVC) insertion is one of the most common minimally invasive procedures globally, necessary for 60-90% of hospitalized patients. Those experiencing high failure rates of the technique are patients. Among the failures of the CVP insertion technique, pain is an important factor that often leads to the request for catheter removal by the patient. Therefore, in order to better manage the pain associated with CVP insertion and to better understand the patient's experience, we decided to conduct a prospective, observational, analytical study using the Visual Analog Scale (VAS).

6.2. Study Objective:

1. The purpose of this study is to evaluate pain tolerance for patients with a peripheral venous catheter inserted using the Visual Analog Scale (VAS).

6.3. Study Objectives:

1. Distribution of pain scores obtained on the visual analog scale by patients in the study group.
2. Statistical analysis of risk and protective factors identified in the study group.

6.4. Materials and Methods

The study was conducted in 2024, involving a sample of 242 patients. Patients were monitored during the insertion and until the removal of the PVC. The VAS, a standard horizontal line with endpoints marked as "0 - no pain" and "10 - worst pain," was used to measure the intensity of perceived pain. Data were collected prospectively and analyzed statistically using Microsoft Excel 2019 for calculating pain prevalence across the six levels and EpiInfo for identifying risk/protection factors. 2x2 contingency tables and χ^2 were used to determine significant associations between independent variables (catheter sizes, age, gender, education level) and dependent variables (the six VAS scores).

6.5. Results

The study sample included patients who had at least one PVC inserted, and pain scale data were collected upon discharge. The demographic distribution of patients was relatively balanced between sexes, with a higher percentage of males compared to females. Patient age was varied, with a significant number of individuals over 65 years old. Most patients had a high school or college education level.

Distribution of reported pain based on PVC sizes used: Most patients received 18G catheters (54.13%) and 20G catheters (35.97%), with a smaller proportion receiving 22G catheters (9.91%). Patients reported varied levels of pain, with approximately one-third describing moderate to severe pain. CVP18G: Associated with a higher prevalence of moderate to severe pain. Severe pain scores (33.58%), moderate pain (25.19%), very severe pain (16.79%), and unbearable pain (9.92%). CVP20G: Associated with mild pain (28.73%) and moderate pain (21.83%). Also reported were severe, very severe, and unbearable pain, but in lower percentages compared to CVP18G. CVP22G: Associated with mild pain (37.5%) and no pain (12.5%), indicating that patients who reported no pain typically had a 22G CVP.

Statistical analysis through cause-effect correlations between the independent variable - CVP size and the dependent variable - pain scores:

- CVP18G acts as a protective factor against the occurrence of mild pain (score 2), compared to other catheter sizes. The results support this hypothesis (χ^2-9.1363, p-0.001389, RR-0.4735).
- CVP18G is a risk factor for the occurrence of severe pain (score 6) (χ^2-8.4652, p-0.00180, RR-1.96222). This means that individuals with CVP18G are more likely to experience severe pain compared to other catheter sizes inserted.
- CVP20G acts as a protective factor against the occurrence of severe pain (score 6), compared to other catheter sizes. The results support this hypothesis (χ^2-4.1199, p-0.0021007, RR-0.6065).

Proportion of reported pain based on age groups:
The analysis of the association between age and pain levels expressed on the VAS scale provides a clear perspective on how pain perception and severity vary across different age categories.

Age group 18-45 years:

- Moderate pain (score 4): Approximately 58.82% of participants report moderate pain.
- Severe pain (score 6): Approximately 29.41% of participants report severe pain. This age group shows a significant proportion of individuals reporting no pain or mild pain, suggesting a relatively higher pain tolerance compared to older age groups.

Age group 46-65 years:

- Moderate pain (score 4): 15.23%
- Severe pain (score 6): 30.47%
- Very severe pain (score 8): 20.95%
- Unbearable pain (score 10): 19.04% This age group highlights a higher prevalence of pain compared to the younger group (18-45 years), reflecting increased health issues associated with age.

Age group over 65 years:

- Mild pain (score 2): 33.33%
- Moderate pain (score 4): 25%
- Severe pain (score 8): 15%
- Very severe pain (score 10): 5.83% This age group shows a moderate distribution of pain compared to the other age groups, indicating a lower prevalence of severe and very severe pain.

Statistical analysis through cause-effect correlations between the independent variable - age and the dependent variable - pain scores:

Age 18-45 years is a risk factor for the occurrence of moderate pain (score 4) (χ2-13.0899, p-0.000627, RR-2.8772). This result suggests increased susceptibility to moderate pain among young adults.

Age 46-65 years acts as a protective factor against the occurrence of mild pain (score 2) (χ2-14.1534, p-0.000065, RR-0.3417). Age 46-65 years acts as a protective factor against the occurrence of moderate pain (score 4) (χ2-6.5123, p-0.005301, RR-0.5219). Age 46-65 years is a risk factor for the occurrence of severe pain (score 6) (χ2-6.5601, p-0.005738, RR-1.7397). Age 46-65 years is a risk factor for the occurrence of unbearable pain (score 10) (χ2-11.6502, p-0.000392, RR-3.7279). This result indicates increased vulnerability to severe pain in this middle-aged category.

Age over 65 years acts as a protective factor against the occurrence of unbearable pain (score 10) (χ2-6.8060, p-0.00473, RR-0.3558). Age over 65 years acts as a protective factor against the occurrence of severe pain (score 6) (χ2-7.3287, p-0.03545, RR-0.3455). Age over 65 years is a risk factor for the occurrence of mild pain (score 2) (χ2-18.1892, p-0.000009, RR-3.1282). This result suggests increased susceptibility to mild pain among the elderly.

Proportion of reported pain based on gender of patients in the sample: Women: Mild pain (score 2): 27.95%, Moderate pain (score 4): 26.88%. Women report higher percentages for mild and moderate pain compared to men. Men: Severe pain (score 6): 28.18%, Very severe pain (score 8): 18.79%, Unbearable pain (score 10): 13.42%. Men tend to report higher percentages for severe, very severe, and unbearable pain compared to women.

Statistical analysis through cause-effect correlations between the independent variable - gender of patients and the dependent variable - pain scores show no statistical significance.

Proportion of reported pain based on the educational level of patients in the sample: The analysis of the association between education level and pain levels reported on the VAS scale indicates significant differences in pain perception and reporting based on education:

Low Education: Most frequently reported score: 2 - Mild pain, with a prevalence of 50.00%. Individuals with lower education levels more frequently report mild pain compared to other pain levels. Medium Education - High School Graduates: Patients with completed high school most frequently reported moderate pain score - 4, with a prevalence of 30.00%. Higher Education: Patients with college degree - Most frequently reported score is 6 - Severe pain, with a prevalence of 28.57%. Patients with a master's degree - Most frequently reported score is 4 - Moderate pain, with a prevalence of 50.00%. Analyzing the reported prevalences at each education level, we observe significant differences in how they perceive and report different pain levels, reflecting, in part in our opinion, the influence of education on pain perception and communication.

Statistical analysis through cause-effect correlations between the independent variable - education level of patients and the dependent variable - pain scores:

Low Education acts as a protective factor against the occurrence of very severe pain score - 8. (χ2-5.5974, p-0.005927, RR-0.2368). Low Education is a risk factor for the occurrence of mild pain score - 2. (χ2-24.8246, p-0.000002, RR-3.1935). Medium Education - Statistical analysis through cause-effect correlations between the independent variable - medium education and the dependent variable - pain scores show no statistical significance.

Higher Education acts as a protective factor against the occurrence of pain score 2 - mild pain. (χ2-15.2537, p-0.000097, RR-0.3397). Higher Education is a risk factor for the occurrence of pain score 8 - very severe pain. (χ2-10.8439, p-0.000549, RR-2.7083). Higher Education is a risk factor for the occurrence of pain score 10 - unbearable pain. (χ2-5.0800, p-0.013415, RR-2.3214).

Table No. 6 Risk Factors Identified versus Protective Factors

No.	Pain Score	Risk Factors	Protective Factors	Total
1.	0: No pain	0	0	0
2.	2: Mild pain	- Over 65 years old Minimal studies	CVP18G 46-65 years Higher education - university	2R 3P
3.	4: Moderate pain	18-45 years	46-65 years	1R 1P
4.	6: Severe pain	CVP 18G 46-65 years	CVP20G Over 65 years old	2R 2P
5.	8: Very severe pain	Higher education - university	Minimal studies	1R 1P
6.	10: Unbearable pain	46-65 years Higher education - university	Over 65 years old -	2R 1P

Portrait of Ideal Pain Tolerance Based on Validated Factors:

Age: Over 65 years old - protective factors for mild pain (score 2), severe pain (score 6), and unbearable pain (score 10). Education Level: Minimal - individuals with minimal education are protective factors against severe pain (score 8). Use of 20G peripheral venous catheter (PVC) - protective factor against severe pain (score 6).

Summary of the Portrait: Age: Over 65 years old Education Level: Minimal Use of Peripheral Venous Catheter: 20G PVC

This portrait combines characteristics that have been associated with a lower risk of experiencing higher levels of pain, indicating good pain tolerance.

6.6. Discussions:

Schofield P and Abdulla A (2018), in a systematic review of evidence-based guidelines for pain assessment in older adults, examined the evidence on the effectiveness of pain assessment strategies in this demographic. Their results describe variations in pain prevalence among the elderly, ranging from a minimum of 0% to a maximum of 93%, clearly illustrating how methods and definitions used can influence prevalence estimates. Significant age-related differences were observed. Communication challenges are essential, highlighting the need for education and continuous training of healthcare providers to improve recognition and management of pain in the elderly. Similarities to our study findings are relevant as we also used the Visual Analog Scale (VAS) for pain assessment in our study population, which predominantly consisted of elderly patients, with only 7.02% being young adults aged 18-45 years. Recommendations from both studies emphasize the importance of increasing education levels and ongoing training for healthcare providers.

Different sizes of PVC (18G, 20G, 22G) were associated with varying levels of discomfort and pain. PVC size can significantly influence patient sensations, where smaller sizes like 22G are associated with less pain compared to larger sizes (18G). Proper selection of PVC size can reduce discomfort and improve patient experience during and after insertion procedures. These findings underscore the need for personalized strategies in pain assessment and management for the elderly and the importance of choosing the appropriate PVC size to minimize patient discomfort.

Individuals with higher education levels appear to be protected against mild pain but have a higher risk for severe and unbearable pain. This indicates a complex influence of education level on how individuals perceive and manage pain, necessitating tailored strategies for different educational levels.

6.7. Conclusions:

Regarding PVC size correlated with pain scores on the VAS:

18G PVC: severe pain has the highest prevalence in the study population - 69.84%, statistically confirmed as a significant risk factor ($\chi^2 = 8.4652$, $p = 0.00180$).

20G PVC: severe pain accounts for 25.39% of the study population, statistically established as a protective factor ($\chi^2 = 4.1199$, $p = 0.0021007$).

Age and Pain Scores: Validation of percentages through statistical analysis:

18-45 years old: moderate pain with a prevalence of 17.85% in the study population, confirmed as a statistically significant risk factor ($\chi^2 = 13.0899$, $p = 0.000627$).46-65 years old: moderate pain with a prevalence of 28.57% in the study population, established statistically as a protective factor ($\chi^2 = 6.5123$, $p = 0.005301$), and severe pain with a prevalence of 57.14% in the same conditions, validated as a risk factor ($\chi^2 = 6.5601$, $p = 0.005738$).

Unbearable pain with a prevalence of 74.07% in the study population, confirmed as a statistically significant risk factor ($\chi^2 = 11.6502$, $p = 0.000392$).

Over 65 years old: mild pain with a prevalence of 75.47% in the study population, confirmed as a statistically significant risk factor ($\chi^2 = 18.1892$, $p = 0.000009$).

Unbearable pain with a prevalence of 25.92% and severe pain with a prevalence of 45.00% under the same conditions, ($\chi^2 = 7.3287$, $p = 0.03545$), are confirmed statistically as protective factors.

Patients' Gender and Pain Scores: Gender did not show statistically significant validation.

Education Level and Pain Scores:

Minimal education: mild pain with a prevalence of 64.51% in the study population, confirmed as a statistically significant risk factor ($\chi^2 = 24.8246$, $p = 0.000002$).

Medium education: no statistically significant validation.

Higher education: mild pain with a prevalence of 45.16% in the study population, established as a statistically significant protective factor (χ 2-15.2537, p-0.000097, RR-0.3397).

Severe pain with a prevalence of 72.50% in the study population, confirmed as a risk factor (χ 2-10.8439, p-0.000549, RR-2.7083).

Unbearable pain with a prevalence of 66.66% in the study population, confirmed as a risk factor (χ 2-5.0800, p-0.013415, RR-2.3214).

7. Final Conclusions

Following the discussion of omissions during peripheral venous catheter (PVC) insertion in the initial stage, diligent healthcare providers who reperformed the procedure with prior alertness reduced the omission rate from 48.89% to 20.35%.

Most failures were recorded during the insertion of the 18G PVC into the median vein. The experience of medical assistants played a crucial role, with those having 0-1 years of tenure at the same workplace showing the highest failure rates.

Statistical analysis validated the 18G peripheral venous catheter as a significant risk factor. Our study indicates that the insertion of a 22G PVC into the median vein, maintained for a clinical duration of less than 25 hours, has a positive and significant impact on procedural success.

Additionally, we identified an ideal profile for patients who tolerate pain better following this procedure, based on certain validated protective factors:

- Age: Individuals over 65 years old are less susceptible to pain, significantly protected against mild, severe, and unbearable pain.
- Education Level: Individuals with minimal education have additional protection against very severe pain.
- Catheter Type: Use of a 20G peripheral venous catheter is associated with a reduced risk of severe pain.

This profile combines these characteristics to identify patients with better pain tolerance in the context of PVC use. Therefore, selecting patients according to these criteria can contribute to improving their experience and comfort during and after peripheral venous catheter insertion.

7.1. Doctoral Thesis Innovation

The novel elements of the research include:

Detailed structuring based on criteria/items of the three steps of peripheral venous catheter insertion technique. The analysis treated each step individually, with Time 1 and 3 belonging to a single assistant, while Time 2 of manipulation and maintenance involved a larger number of assistants depending on the catheter maintenance duration. The importance of repeated trainings, supported by evidence and providing constant feedback, significantly reduces the frequency of omissions in the PVC technique. The practical monitoring mode of the PVC insertion technique demonstrated its benefits compared to theoretical training, as it offered a clear understanding and validation of potential omissions and critical points.

The innovative element of the research in Study 2 lies in identifying and clearly defining failures observed in monitoring the process of peripheral venous catheter insertion (PVC), categorizing each failure code recorded into one of the three working times during which it occurred. By focusing on the exact moment of failure during the procedure, we can better understand the context and factors contributing to its occurrence, thus enabling us to develop preventive strategies in clinical practice.

Statistical validation of 18 risk factors and 14 protective factors identified demonstrates that failures are caused not only by inadequate techniques but also by patient characteristics and statistically validated variables. Understanding these validated risks and utilizing identified protective factors allows us to optimize clinical procedures, thereby reducing failure rates and improving the quality of patient care.

Study 4 addresses a gap in scientific research, specifically studying patient reaction during PVC insertion and until its removal. We utilized VAS pain scale analysis performed at patient discharge to obtain an objective understanding of their experience. We statistically validated risk and protective factors based on different pain scores correlated with variables such as age, PVC size, and education level. Results showed that age over 65 and use of smaller catheter sizes are protective factors against pain. Additionally, we validated factors supporting the theory that higher education aids in better pain management during insertion.

7.2. Utility of Research Results

Improving clinical practices and supplementing guidelines with practical findings is highly practical. Research results could be used in continuous training programs and periodic training of assistants involved in peripheral venous catheter insertion and care, thereby increasing their competence and patient safety.

Discoveries from the study can guide training and instructional programs for healthcare assistants and medical staff involved in peripheral venous catheter insertion and management. This could contribute to enhancing procedural competence and safety. Research results propose inclusion in PVC insertion techniques, including statistically validated risk and protective factors.

Understanding patient pain-related risk factors associated with PVC insertion can lead to developing strategies that could improve patient comfort during catheter use. Identifying risk and protective factors associated with PVC insertion can help optimize resource utilization concerning catheter size selection and care planning. This can lead to more efficient material use and reduced costs associated with managing complications and failures.

Opportunities for Future Research

This thesis can serve as a basis for further research in the field of peripheral venous catheter insertion and management. Identifying knowledge gaps or areas needing further investigation can guide future directions.

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