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ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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# The Effects of Three-way Stopcock and Split Septum Injection Valve Usage on Catheter Infection and Colonization: A Quasi-Experimental Study

## Üç Yollu Musluk ve Split Septumlu Enjeksiyon Valfi Kullanımının Kateter Enfeksiyonu ve Kolonizasyonuna Etkileri: Yarı Deneysel Çalışma

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**This study was prepared based on the findings of Hilal TÜRKBEN POLAT's thesis study titled "The effects of three-way stopcock and split septum injection valve usage on catheter infection and colonization" (Malatya: İnönü University; 2016).*
**This study was presented as a verbal presentation at 5th International and 16th National Nursing Congress, November 5-8, 2017, Antalya, Türkiye.*

**ABSTRACT Objective:** Connectors are frequently and necessarily used in patients undergoing intravenous fluid therapy. All of the catheters and connectors may be a risk factor for catheter infections if aseptic techniques were not used. This study was conducted to determine the effect of 3-way stopcock (3WSC) and Split Septum Injection Valve (SSIV) Usage on peripheral intravenous catheter colonization and infection. **Material and Methods:** This is a quasi-experimental study. The sample of the study consists of 216 patients (108 control, and 108 experimental group). 3WSC was integrated to the control group and SSIV was integrated to the experiment group peripheral venous catheters. Catheters were observed for 72 hours in terms of complications such as bleeding, leakage, and phlebitis infiltration. Catheters were removed for culture sampling 72 hours after catheterization. Descriptive statistics and Pearson chi-square were used in the analysis of the data. **Results:** The rate of colonization was 5.6% in 3WSCs and 2.8% in SSIVs. When the colonization rates were compared, there was no statistically significant difference between 3WSCs and SSIVs about catheter colonization and infection (p>0.05). **Conclusion:** Both connectors can be used safely in the administration of continuous intravenous solution and drug therapy. Development of continuous in-service training programs for the prevention of catheter related blood system infections are suggested.

**Keywords:** Catheter-related infections; peripheral venous catheterization; catheter care

**ÖZET Amaç:** Konnektörler, intravenöz sıvı tedavisi alan hastalarda sıklıkla ve zorunlu olarak kullanılır. Aseptik teknikler kullanılmazsa, tüm kateterler ve konektörler kateter enfeksiyonları için bir risk faktörü olabilir. Bu çalışma, 3 yollu musluk [3-way stopcock (3WSC)] ve split septumlu enjeksiyon valfinin [Split Septum Injection Valve (SSIV)] periferik intravenöz kateter kolonizasyonu ve enfeksiyonu üzerindeki etkisini belirlemek amacıyla yapılmıştır. **Gereç ve Yöntemler:** Araştırma, yarı deneysel bir çalışmadır. Araştırmanın örneklemini 216 (108 kontrol ve 108 deney grubu) hasta oluşturmaktadır. Kontrol grubuna 3WSC, deney grubu periferik venöz kateterlere SSIV takılmıştır. Kateterler kanama, sızıntı, flebit, infiltrasyon gibi komplikasyonlar açısından 72 saat gözlemlenmiştir. Kateterizasyondan 72 saat sonra kültür örneklemesi için kateterler çıkarıldı. Verilerin analizinde, tanımlayıcı istatistikler ve Pearson ki-kare kullanılmıştır. **Bulgular**: Kolonizasyon oranı 3WSC'lerde %5,6 ve SSIV'lerde %2,8 idi. Kolonizasyon oranları karşılaştırıldığında, 3WSC'ler ve SSIV'ler arasında kateter kolonizasyonu ve enfeksiyonu açısından istatistiksel olarak anlamlı bir fark yoktu (p>0,05). **Sonuç:** Her iki konnektör de sürekli intravenöz solüsyon uygulamasında ve ilaç tedavisinde güvenle kullanılabilir. Kateter ilişkili kan dolaşımı enfeksiyonlarının önlenmesi için sürekli hizmet içi eğitim programlarının geliştirilmesi önerilmektedir.

**Anahtar Kelimeler:** Kateter ilişkili enfeksiyonlar; periferik venöz kateterizasyon; kateter bakımı

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Health care-associated infections are the serious problem of health system all over the world. Many people are hospitalized due to health care-associated infections.[1] Catheter-related bloodstream infections (CRBSIs) are one of the important health care-associated infections also according to CRBSIs mortality and morbidity rates are increasing.[2] Microorganisms may infiltrate by peripheral venous catheters (PVCs) and connectors and may cause CRBSIs if aseptic techniques were not used.[3,4]

Intravenous (IV) catheterization is one of the indispensable applications of modern medicine. Many patients admitted to hospital receive IV treatment. Catheter related infections cause prolonged hospital stay of patients and their relatives, loss of labor and time for the patient, prolonged work of the medical team and economic losses. In the case of IV fluid treatment, if more than one fluid and drug treatment should be provided at the same time, some special IV connectors should be used. Although these provide convenience in application, they pose an additional risk in terms of catheter colonization and infection in treatment.[5,6]

IV connectors were designed for health care workers especially for nurses safety, to prevent needlestick injury and blood born patogens infection and they can be used to receiving multiple fluid therapy. Although these connectors are used with PVCs, it is still unknown how this affects development of colonization and catheter infection.[5,6]

Three-way stopcocks (3WSCs) and needle free connectors (NFCs) are frequently used in IV fluid therapy clinical settings. NFCs provide needle-free access for IV drug administration, infusion, taking blood samples, or connecting other IV sets to the PVCs.[7] The standard SSIVs are also used for IV infusion or medication administration.[8] Centers for Disease Control and Prevention advised that split-septum valves may be preferred over some mechanical valves when needleless systems are used.[1,9]

Both of these connectors are used with the nurses' preferences. There are different studies comparing these two connectors about CRBSI. According to literature, there was no difference between two types of connectors on the development of CRBSI.[9-11] Also there are studies that NFCs are much safer in reducing the risk for infection.[8,12-15] If aseptic techniques were not used, needleless systems may be a risk factor for CRBSI for all types of catheters.[16] This research is important in terms of determining the effects of these two connectors, which are frequently used in IV fluid therapy, on microbiological colonization and infection. According to this information, the research was carried out to determine the effect of 3WSCs and SSIVs on PVC colonization and catheter infections.

## MATERIAL AND METHODS

### Aim

The aim of this study was to determine the effect of 3WSCs and SSIVs on PVC colonization and infection.

### Hypothesis

$H_0$: There is no significant difference in microbiological colonization of catheters between the 3WSCs and SSIVs integrated PVCs.

$H_1$: There is a significant difference in microbiological colonization of catheters between the 3WSCs and SSIVs integrated PVCs.

### STUDY DESIGN

This is a quasi-experimental study that included experimental and control groups.

### POPULATION AND SAMPLING

The study was conducted between October 2015 and September 2016 at the general surgery department of a hospital. Adults who were placed PVCs in the general surgery clinic, who had no disability to communicate, were hospitalized for more than 72 hours, receiving multiple fluid therapy at the same time, being hospitalized due to causes except infection are the inclusion criteria. Patients whose PVCs removed without the knowledge of the researcher and patients with PVC complication after catheterization were excluded.

Power analysis was used to find the number of study sample. Before the study, number of sample was calculated. The sample size was found to have a

level of significance of 0.05 and power of the population representation of 0.95, the sample was determined to be 216. The study sample included 108 controls and 108 subjects in the experimental group. However, because of the infiltration 43 participants, 12 patients due to early discharge were excluded from the research.

### DATA COLLECTION

Data were collected by the descriptive information form and catheter follow-up forms.

**Descriptive information form:** It consists of 15 questions about age, gender, chronic disease, communication status, previous illnesses and surgeries, when the patient last received IV application, whether there were any complications in previous IV application and mastectomy.

**Catheter follow-up forms:** The form includes the date and time of application, application site, connectors used, dressing look and dressing change time. Also the forms include complication such as infiltration, phlebitis, thrombophlebitis and embolism, catheter removal reason and culture result. Both of the forms were created according to literature by the researcher.[1,3,6]

### PRACTICE OF THE RESEARCH

PVCs and connectors were placed in order to perform IV infusion and drug applications. PVCs were placed to one of the suitable cephalic, basilic and metacarpal veins of the patients by the researcher. PVCs were inserted on the non-mastectomy arm in patients with mastectomy. The vein was selected by randomization. 0.9 Gx25 mm non-pyrogenic PVC with 22 G is preferred. Skin was cleaned and stayed for 2 minutes to dry. 10% povidone iodine was used for skin cleansing and catheter dressing change.[6] After PVC was placed to vein, 3WSCs integrated to the control group and SSIVs was integrated to the experiment group. Closure and fixation is done with sterile transparent dressing. The catheter dressing was changed every 24 hours and also when it loosened, disintegrated and contaminated. PVCs were followed up daily by the researcher in terms of swelling and redness. PVC was removed if any complications occurred. 10% povidone iodine was used for skin cleansing and catheter dressing change.[6] Nurses were trained about the study. Because all of the IV medication and fluid therapies were practiced by the clinical nurses.

PVC samples were taken by the researcher, 72 hours after the catheterization. The skin was cleaned and stay for 2 minutes to dry. The PVC was removed and catheter tip was cut by aseptic technique. The catheter tips were sent to the laboratory and placed into a blood agar. Catheter tips were studied in the microbiology laboratory to be evaluated for bacterial colonization. Semi-quantitive method was used to assess colonization of bacteria in the catheter tips. In semi-quantitative culture, the colonization was explained as microorganism count equal or higher than 15 CFU/plate.[6]

### DATA ANALYSIS

SPSS for Windows 20.0 (Chicago, USA) program was used for the analysis of data. Data were analyzed using descriptive statistics and Pearson chi-square tests. The results were considered statistically significant at the 95% confidence interval and $p<0.05$ error level.

### ETHICAL CONSIDERATION

Before the research, the ethical approval (Malatya Clinical Researches Ethics Committee, Date: 16.12.2015, no: 2015/200) and the written permission from the hospital were obtained. The aim of the study was explained to participants. Verbal and written informed consent was obtained from each of the participants. All physicians and nurses working in the general surgery clinic were informed about the research. General surgery clinic nurses were given pre-study training about the use of a 3WSCs and SSIVs. The research was carried out in accordance with the principles of the Helsinki Declaration.

## RESULTS

In this study, the PVC colonization was compared for two groups. 21.3% of the SSIVs and 23.1% of the 3WSCs patients had gastrointestinal system cancers. It was determined that 63.9% of the SSIVs and 68.5% of the 3WSCs integrated patients used antibiotics.

When age, chronic disease status, previous operations, mastectomy, application site, antibiotic use

examined, the difference between the SSIVs and 3WSCs, it was found to be statistically insignificant (p>0.05) .When IV solution and diagnosis were examined, the difference between the SSIVs and 3WSCs integrated catheters, it was found to be statistically significant (p>0.05) (Table 1).

The rate of colonization was 5.6% (n=6) in 3WSCs and 2.8% (n=3) in SSIVs. When the colonization rates were compared, the difference was found to be statistically insignificant (p>0.05) (Table 2). Colonization levels were not high enough to develop catheter infection.

## DISCUSSION

PVCs are used for most hospitalized patients and they may be a risk factor for CRBSIs. 3WSCs or NFCs are used in clinical practice to reduce the risk of needle injury, to prevent accidental openings of entry ports, receiving multiple fluid therapy and to facilitate aseptic technique.[17]

In the study, there is no significant difference between 3WSCs and SSIVs groups in terms of age, chronic disease, previous operations, mastectomy, application site or antibiotic use. These variables may be associated with catheter colonization and infection.[10] Thus, the effects of the variables, in the development of infection, are minimized. When IV solution and diagnosis examined, the difference between the SSIVs and 3WSCs was found to be statistically significant. Similar to our study, there was no difference between the groups in terms of variables such as age, disease, and gender in the study of Sengul et al.[11]

In the study, the rate of reproduction was 5.6% in catheters with 3WSCs and 2.8% in catheters with SSIVs. There was no statistically significant difference in colonization between 3WSCs and SSIVs groups. *Staphylococcus epidermidis* grows in catheter tips, colonization level of the tips were not enough to create catheter infection. There is no catheter infection in the participants. Oto et al. compared the device with NFCs and 3WSCs, they found microbiological contamination in the NFCs 10%, while the 3WSCs was to be 8%.[10] Pohl et al., found the colonization rate 0% catheters with NFCs, whereas the colonization rate 8% with 3WSCs.[18] Küçüker reported a 6.7% colonization rate in catheters with 3WSCs and no colonization in catheters with NFCs.[19] There are different studies comparing these two connectors about CRBSI. Some of the studies stated that there was no difference between two types of connectors on the development of CRBSI.[9-11,18,19] Studies determined that NFCs are much safer in reducing the risk for catheter infection.[12-14] In a meta-analysis, it is reported that CRBSI risk was statistically higher for 3WSCs compared to NFCs.[8]

According to the literature, it is seen that this kind of research is generally done on central venous catheter. Rosenthal et al. stated that SSIVs with single-use prefilled flushing devices are more cost effective and associated low catheter infection rate compared with 3WSCs.[20] González López et al. reported that open systems were associated with more phlebitis when compared with closed systems.[21] Also it was stated that 11% of PVCs were colonized with micro-organisms.[22]

The most important factor is health care workers' and nurses' practices for the safety of connectors. It was determined that NFCs may be used safely if aseptic techniques were used.[16] The 3WSCs and SSIVs are used when more than one medication or fluid is required at the same time. Both products may be an important risk factor for catheter infections in PVCs if not used properly. In the clinics where this study was conducted, nurses were constantly informed about the safe use of 3WSCs and SSIVs in order to reduce the factors that may affect bacterial colonization in drug or IV fluid applications. Using aseptic technics is very important to reduce colonization and catheter infections.

It is very important to ensure hand hygiene, aseptic technique usage and continuous and effective inservice training to reduce catheter infections. If health care professionals follow the recommended guidelines, both products may be preferred in the administration of IV fluid and drug therapy.

### LIMITATION OF THE STUDY

The present study was conducted only in a hospital. It is recommended to study with larger populations.

**TABLE 1:** Descriptive characteristics of participants (n=216).

| | SSIVs | | 3WSCs | | |
|---|---|---|---|---|---|
| **Characteristics** | **n** | **%** | **n** | **%** | **p value** |
| Age | | | | | |
| 20-39 | 30 | 27.8 | 36 | 33.3 | $\chi^2$=2.860 |
| 40-59 | 32 | 29.6 | 38 | 35.2 | p=0.239 |
| 60 and above | 46 | 42.6 | 34 | 31.5 | |
| Sex | | | | | |
| Female | 64 | 59.3 | 63 | 58.3 | $\chi^2$=0.19 |
| Male | 44 | 40.7 | 45 | 41.7 | p=0.890 |
| Chronic disease status | | | | | |
| None | 85 | 78.7 | 85 | 78.7 | $\chi^2$=2.848 |
| Hypertension | 12 | 11.1 | 10 | 9.3 | p=0.723 |
| Diabetes mellitus | 8 | 7.4 | 8 | 7.4 | |
| Other | 3 | 2.8 | 5 | 4.6 | |
| Previous operations | | | | | |
| Yes | 43 | 39.8 | 44 | 40.7 | $\chi^2$=0.019 |
| No | 65 | 60.2 | 64 | 59.3 | p=0.890 |
| Mastectomy | | | | | |
| Yes | 4 | 3.7 | 2 | 1.9 | $\chi^2$=0.686 |
| No | 104 | 96.3 | 106 | 98.1 | p=0.408 |
| Diagnosis | | | | | |
| Gis cancers | 23 | 21.3 | 25 | 23.1 | |
| Liver surgery, cholecystectomy | 29 | 26.9 | 24 | 22.2 | $\chi^2$=11.117 |
| Bariatric surgery | 12 | 11.1 | 29 | 26.9 | **p=0.025** |
| Abdominal pain ileus | 20 | 18.5 | 17 | 15.7 | |
| Other | 24 | 22.2 | 13 | 12.1 | |
| Catheter side | | | | | |
| Right cephalic vein | 19 | 17.6 | 13 | 12.0 | |
| Right basilic vein | 18 | 16.7 | 30 | 27.8 | |
| Left cephalic vein | 20 | 18.5 | 20 | 18.5 | $\chi^2$=4.606 |
| Left basilic vein | 21 | 19.4 | 20 | 18.5 | p=0.466 |
| Right metacarpal vein | 17 | 15.7 | 14 | 13.0 | |
| Left metacarpal vein | 13 | 12.0 | 11 | 10.2 | |
| Antibiotic use | | | | | |
| Yes | 69 | 63.9 | 74 | 68.5 | $\chi^2$=0.517 |
| No | 39 | 36.1 | 34 | 31.5 | p=0.472 |
| IV solution | | | | | |
| 0.9% NaCl | 24 | 22.2 | 42 | 38.9 | $\chi^2$=13.136 |
| Ringer lactate | 23 | 21.3 | 31 | 28.7 | **p=0.004** |
| Isolyte S | 26 | 24.1 | 15 | 13.9 | |
| 5% dextroz | 35 | 32.4 | 20 | 18.5 | |

SSIV: Split Septum Injection Valve; 3WSC: 3-way stopcock; IV: Intravenous.

## CONCLUSION

In the present study, there was no statistically significant difference in catheter colonization between 3WSCs and SSIVs groups integrated with PVCs. However, more colonization should be considered in 3WSCs. The results of this research will guide nurses in raising awareness about these connectors that they frequently use.

**TABLE 2:** Colonization rates according to the type of connector.

| | SSIVs | | 3WSCs | | Total | | |
|---|---|---|---|---|---|---|---|
| **Patogens** | **n** | **%** | **n** | **%** | **n** | **%** | **p value** |
| No reproduction | 105 | 97.2 | 102 | 94.4 | 207 | 95.8 | $\chi^2$=1.403 |
| *Staphylococcus epidermidis* | 3 | 2.8 | 6 | 5.6 | 9 | 4.2 | p=0.307 |

SSIV: Split Septum Injection Valve; 3WSC: 3-way stopcock.

With the results obtained from the research, the following suggestions are presented:

- Development of continuous in-service training programs for the prevention of CRBSIs.
- Both products can be used safely in the administration of continuous IV solution and drug therapy.
- Further studies should be conducted about the subject.


### *Source of Finance*

*During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.*

### *Conflict of Interest*

*No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.*

### *Authorship Contributions*

*All authors contributed equally while this study preparing.*


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