RECEBIDO: JUNHO 2018; ACEITE: AGOSTO 2018; PUBLICADO ON-LINE: NOVEMBRO 2018
https//doi.org/10.31877/on.2018.37.01

# IMPROVING A BETTER NURSE PRACTICE ASSOCIATED WITH THE MANIPULATION OF CVC AND NEEDLELESS CONNECTORS

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**RESUMO:** Com o aumento do número, frequência e duração dos tratamentos de quimioterapia, o incremento do uso de cateteres centrais de longa duração permitiu a administração de terapia intravenosa, suporte transfusional e colheita sanguínea de uma forma mais segura e eficaz. Uma das recomendações para manipular o CVC em segurança foi o uso de conectores sem agulha, sendo fundamental o conhecimento das implicações desses dispositivos na prática de enfermagem.

**Objetivo:** Este estudo visa melhorar a prática associada à manipulação do CVC, usando um duplo conector sem agulha, numa população de pessoas com leucemia aguda (LA) submetidos a quimioterapia de altas doses.

**Métodos:** Foi realizado um estudo comparativo prospetivo unicêntrico, incluindo uma amostra-consecutiva de todas as pessoas diagnosticadas com LA, portadoras de CVC tipo Hickman®, com conector sem agulha simples (SSNC) (grupo 1) ou duplo conector sem agulha (DSNC) (grupo 2), em fase de quimioterapia ou aplasia, desde dezembro de 2014 a dezembro de 2016, na Unidade de Onco-Hematologia do Instituto Português de Oncologia do Porto.

**Resultados:** No total, foram estudados 17 pessoas com LA que reportaram 78 internamentos [mediana 4, intervalo 1 a 12], 1.122 dias de admissão [mediana de 12.5, intervalo 3 a 44] e 1.044 dias de CVC [mediana 12, intervalo de 3 a 35]. Não foi encontrado nenhum risco estatisticamente significativo de infeção associada ao CVC entre os grupos de estudo [RR 0.4528, IC 95%, 0.1235-1.6605], no entanto, aquando da identificação de colonização da linha central esta reportava-se sempre ao grupo 1. Todas as hemoculturas positivas foram reportadas em períodos de neutropenia. Nenhuma infeção relacionada com o CVC foi identificada.

**Conclusão:** O estudo sugere que o DSNC pode ser uma boa escolha para a prática de enfermagem de forma a reduzir o risco de colonização do cvc e melhorar a segurança da sua manipulação em pessoas com LA submetidos a quimioterapia em altas doses.

**PALAVRAS-CHAVE:** Conector sem agulha; Leucemia Aguda; CVC; CLABSI.

ABSTRACT: *Background: With the increase in the number, frequency and duration of treatments,*

*long-term catheters were needed to allow different and continuous administration of intravenous therapy, transfusion support and blood sampling. Since many years, the use of needleless connectors is recommended on central-lines access, being crucial the knowledge of the implications associated with the use of these long terms central venous catheters (CVC).*

*Purpose: This study aims the improvement of the CVC management, using a double lumen extension line with needleless connectors, in acute leukemia (AL) patients population undergoing high dose chemotherapy treatments.*

*Methods: A single-centre, prospective comparative study was performed, including all consecutive AL patients using a long-term double lumen silicone CVC (commonly named Hickman® type), with single access (group 1) or double lumen extension with needleless connectors (group 2), undergoing chemotherapy treatment (CT) or aplasia support from December 2014 to December 2016 at the Haematology Department of the Portuguese Institute of Oncology of Porto.*

*Results: Overall 17 AL patients reporting 78 hospital admissions [median 4, range 1 to 12], 1.122 admission days [median of 12.5, range 3 to 44] and 1.044 CVC-days [median 12, range 3 to 35] were studied. Considering the central line reports, no significant CLABSI risk was determined between study groups [RR 0.4528, 95 % CI, 0.1235-1.6605], however, the central line colonization was always reported in the SSNC group. All positive blood cultures were reported undergoing neutropenia. None CRBSI was identified.*

*Conclusion: The study suggests that the DSNC can be a good option to the nursing practice that aims the reduction of the central line colonization risk and improves a safety CVC management in AL patients undergoing high dose chemotherapy.*

**Keywords:** *Needleless connector; Acute Leukemia; CVC; CLABSI.*

## Introduction

In 1929 Werner Forssmann discovered a new safety method in animals to introduce cardio-active drugs inserting a long urinary catheter via the antecubital fossa to the heart. He was awarded in 1956 with the Nobel Prize (Levin SM, 2014); this was considered the first step in the journey of the central venous catheters (CVC). With the fast growth of the type and number of treatments, new kind of long-term catheters were needed which could support the administration of intravenous therapy, transfusion support and blood sampling (Martinez JM, et al, 2015). The Hickman® catheter type is a cuffed double lumen long--term silicone central venous catheter, which commonly is placed percutaneously in the subclavian or internal jugular vein. Usually the 2 lumens differ in terms of the internal diameters, presenting a wider lumen (can be used for transfusional support or total parenteral nutrition) and another with a smaller diameter.

Associated to all CVC's, infections and occlusions can be considered the most important complications associated with the CVC management. In the particular case of Acute Leukemia (AL) patient population, the neutropenia condition increases the number of CVC manipulations (more blood samples, transfusion support and blood cultures collection) leading to a higher risk of CLABSI (central line associated bloodstream infection) (Martinez JM, et al, 2018). When the CVC is considered the infection source, it is reported CRBSI (catheter-related bloodstream infection), being the most important cause and indication for CVC removal (Mermel LA, 2011).

A catheter-related occlusion is considered when the capacity to blood withdrawal and flush fluids is compromised (Baskin JL, et al, 2009). The catheter-related occlusion could affect the normal CVC functionality, for example by inability to aspirate blood but ability to infuse through the catheter (partial occlusion) or inability to aspirate blood and infuse through the catheter (complete occlusion) (Hoffman R, 2013).

The use of needleless connectors is recommended for central-line accessing (CDC, 2011). They are used to create a safer and easier catheter access (CDC, 2011). The split septum needleless connectors (SSNC) are considered the first generation of these devices, being followed by the mechanical valve with positive pressure (MVC-PP). In the available literature, SSNC are linked to lower infection rates when compared with MVC-PP (Martinez JM, et al, 2018; Joint Commission, 2012). Additionally, in many situations, a 3-way stopcock is suggested as an operational choice device when the system needs to be opened for blood sampling, transfusion support administration and multiple continuum infusions (ex: chemotherapy treatment protocols), however, the 3-way stopcocks were reported to pose a higher infection risk. (Oto J, et al, 2012)

This study tries to improve the CVC management, using a double lumen extension line provided with split septum needleless connectors (DSNC), in a AL patient population associated with a higher rate of device use and complex/dynamic treatment protocols. (Martinez JM, et al, 2018).

## Material and methods

### Selection and description of participants

A single-centre, prospective comparative study was performed, including all consecutive AL patients using a cuffed double lumen CVC more than 72 hours with single (group 1) or double lumen extension line with needleless connectors (group 2), undergoing chemotherapy treatment (CT) or aplasia support from December 2014 to December 2016 at the Haematology Department of the Portuguese Institute of Oncology of Porto.

Patients older than 18 years old with newly diagnosed or relapsed acute leukemia admitted for CT or aplasia support and with a CVC inserted during the study period were included. Patients in supportive care, who had previous hematopoietic stem cells transplantation, with clinical septicemia at the moment of the CVC introduction, with insertion procedure complications or with acute promyelocytic leukemia diagnosis were excluded. After application of inclusion and exclusion criteria, 18 AL patients were included, which matched the recommended sample, using the Raosoft® sample size calculator, for a 5% margin of error, 95% confidence level and 50% response distribution parameters.

### Study Groups: Technical Information

Group 1: The SSNC was always used; the association of the 3-way stopcock was done in particular cases like the transfusion support and continuum perfusion associated with CT;

Group 2: The DSNC connector was always used for continuum perfusions. When the CVC was locked, then an SSNC was used. If erythrocyte transfusion support was indicated, it was performed in the wider lumen (1,0mm) If this lumen was being used for continuum perfusion while the transfusion support was needed simultaneously, the DSNC line was used while the continuum perfusion was temporary stopped. The erythrocyte transfusion support was never performed in the smaller lumen due to the fluid characteristics.

### Neutropenia and Central-Line Infection definitions

Neutropenia (NCCN, 2017) was considered when ANC (Absolute Neutrophil Count) ≤500 cells. CLABSI and CRBSI rates were calculated considering blood cultures (BC) yielding an organism (positive culture in peripheral vein and at least one CVC-line) per 1.000 CVC-days. Colonization was reported if negative culture in peripheral vein and at least one positive CVC-line was identified. CLABSI was considered in patients with a central line in place within 48-hour period and bloodstream infection that is not related to an infection at another site. (CDC, 2011) When DTP (differential time positivity) is reported, CRBSI was considered (Nemoto T, et al, 2015). Catheter--related occlusion (partial and complete) was calculated considering the occlusion events per 1.000 CVC-days. (Baskin JL, et al, 2009).

### Data collection

Data concerning each patient's background was collected from the medical records. The daily data assessment

ended when the CVC was removed for sepsis or end of treatment. When the final eligible patient was admitted to the study a minimum of one-month follow-up was considered. The baseline demographic data was collected on the day of CVC placement and assessment was encompassed in every hospital admission.

**Technical department information**

The department had 20 beds distributed among eight double rooms, plus four single rooms. All of them were equipped with positive pressure ventilation and HEPPA filters. The insertion of CVCs was performed by medical staff in an operating room located in the department, and daily management of CVCs was performed by nursing staff. During the study period, no other relevant departmental changes were implemented, including CVC insertion, CVC management procedures, indication for BC, and BC assessment.

**Device management**

The management of CVCs followed the CDC (2011) *guideline* recommendations. Standard Lifecath cuffed silicone CVC's (Vygon®) were inserted in the subclavian vein. All catheters were double lumen (CH/F 7, lumen no.1=0.6mm, lumen no.2=1.0mm). No antibiotic prophylaxis was performed. Specific technical information of CVC management included the use of: 2% chlorhexidine in 70% alcohol solution for needleless connector disinfection, SSNC (Bionecteur, Vygon®), DSNC (Octopus, Vygon®) (Figure 1) and sodium heparin 20 IU/ml (Fibrilin®) to CVC-lock.

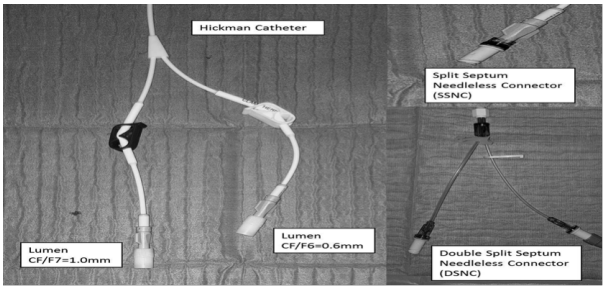


**Figure 1.** Hickman Catheter and Needleless Connectors

**Data analysis**

Data analysis was conducted using IBM SPSS Statistics for Windows (SPSS Inc., Version 23.0). A continuous variable was reported by median and range. Categorical variables were reported as frequency and percentages. Normality tests reported a sample without normal distribution, considering that hypothesis tests were analyzed by non-parametric test. A p value of ≤0.05 was determined to be significant.

**Protection of personal data**

All data was treated in compliance with the Portuguese Law nº 67/98 of 26 October concerning the protection of personal data.

## Results

Overall 17 AL patients among 78 hospital admissions [median 4, range 1 to 12], 1.122 admission days [median of 12.5, range 3 to 44] and 1.044 CVC-days [median 12, range 3 to 35] were studied. The median age was 51.5 [range 20 to 67] with a total number of 11 (61.1%) male patients. The sample reported 56.8% days undergoing neutropenia [n=593, median 12, range 1 to 33], being the induction chemotherapy [n=16 (20.5%)] or aplasia support [n=30 (38.5%)] the most representative neutropenia phases.

Overall 8 CLABSI [median 0, range 0 to 1, 7.7 rate] and 3 central line colonizations [median 0, range 0 to 1, 2.9 rate] were reported. No CRBSI was identified. A total number of 7 catheter occlusions [median 0, range 0 to 1, 6.7 rate] were studied including 6 partial (5.7 rate) and 1 complete (0.9 rate). The partial occlusions were reported with a median of 1 day (range 1 to 2), being the complete occlusion observed across 5 continuum days.

The double lumen extension line with needleless connectors was used in 45 hospital admissions including 662 admission-days [median 13, range 3 to 44] and 625 CVC-days [median 13, range 3 to 35]. (Table 1)

Considering the central line reports, no significant CLABSI risk was determined between study groups [RR 0.4528, 95% CI, 0.1235-1.6605]. The central line colonization was always reported in group 1 (SSNC). All positive blood cultures were reported undergoing neutropenia. No significant differences in catheter-related occlusions were reported between groups, p=.711.

**Table 1.** Comparative central line reports associated with ANC and days between needleless connector groups

| CENTRAL LINE REPORTS | SSNC | DSNC | P |
|---|---|---|---|
| Admission days (ID), n[median (range)] | 460[12(4 to 38)] | 662[13(3 to 44)] | .749 |
| CVC days, n[median (range)] | 419[10(4 to 31)] | 625[13(3 to 35)] | .634 |
| ANC ≤ 500 cells/µL n[median (range)] | 235[13(1 to 23)] | 358[12(1 to 33)] | .380 |
| ANC > 500 cells/µL n[median (range)] | 184[5(1 to 28)] | 271[6(1 to 18)] | .579 |
| Blood Cultures collection, n[median (range)] | 24[0(0 to 3)] | 53[0(0 to 6)] | .560 |
| CLABSI, n[median (range)] | 4[0(0 to 1)] | 4[0(0 to 1)] | .247 |
| Colonization | 3[0(0 to 1)] | 0 | .027 |

## Discussion

In 2013, Cynthia Chernecky and colleagues highlighted that the patient, practice and products could be considered the most important variables associated with the CVC management clinical research, and published "The Healthcare and Technology Synergy (HATS) framework for comparative effectiveness research as part of evidence-based practice in vascular access" (Chernecky C, Zadinsky J, Macklin D & Maeve MK, 2013).

The insertion of every new product should be made with caution especially in populations undergoing neutropenia, which are associated with CT stages (induction, aplasia support and CT cycles), because the risk of central line infection can change across the time. If the neutropenia reports statistical differences between the study groups, the risk of central line infection can be significantly influenced. In consequence, for clinical research the neutropenia can be considered the most representative variable to the risk of central line infection in these patients (Martinez JM, 2017; Martinez JM, 2018). It was suggested in the study "Acute Leukemia patients: a CLABSI risk special population" published in the Annals of Hematology and Oncology, that in neutropenic patients undergoing induction therapy or in aplasia support using the same type of catheters, that the risk of CLABSI increases alongside with cumulative neutropenia days and CVC manipulations (Martinez JM, et al, 2018). Furthermore, the total number of CVC days should be similar between groups because the infection rate can be influenced as well.

### CVC lines and colonization risk

The induction CT causes several difficulties and challenges to the nursing practice, which have to perform CT in continuum perfusions, daily blood sampling, antibiotherapies and a high number of transfusion support administrations, all in the same central vascular device. (Martinez JM, 2017) In these situations, the two lumens from these types of catheters can be considered insufficient in order to deliver and manage the therapeutics with high efficiency. The use of the DSNC increased in 50-100% the number of access points (figure 2), reducing in these cases the necessity of extra peripheral venipuncture, improving the management of capital peripheral venous access. In consequence, the risk of intraluminal DSNC bacteria colonization can also be higher. However, considering the 48-72h biofilm formation risk period (Römling U, et al, 2014), a strict protocol was set in place in our department since 2012, which dictated the exchange of the DSNC every 72 hours or in every BC episode, reducing the potential risk of colonization.

Mollee and colleagues determined in 2011 the incidence and risk factors for CABSI (CLABSI definition according to the Australian Infection Control Association) of all patients requiring a central venous access device (CVAD) in a hematology-oncology department. They considered the CVAD type, patient diagnosis, side of insertion and the number of prior-line insertions as risk factors of CABSI. The study suggests a superior CABSI risk in right-sided lines (HR: 1.60; p=0.027) when a higher

number of previous lines were inserted (HR: 1.2; 95% CI: 1.03-1.41). Study results revealed that progressive use of CVC-lumens doesn't increase the infection risk, being the infection earlier reported in CVCs with more lumens (3 versus 2) (Mollee P, et al., 2011).

This study hypothesizes that the reduction of CVC manipulations close the hub could reduce the risk of intraluminal catheter colonization (Figure 3).

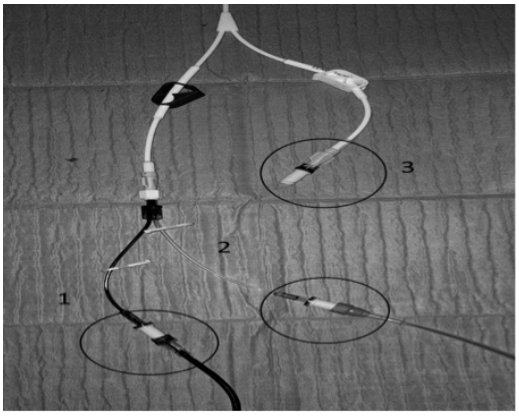


**Figure 2.** Number of provisional lumens and access points

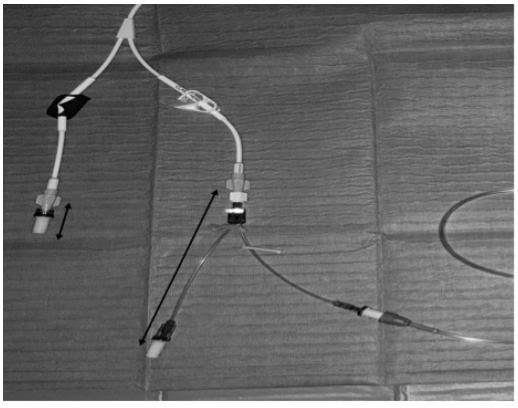

**Figure 3.** CVC manipulation and Needleless connector

The transfusion support administration and high-risk therapeutics were performed using the 3-way stopcock in order to increase the procedure security in group 1. In these procedures, the CVC-line was opened through the SSNC manipulation (close of the hub). With the introduction of the DSNC, the continuum perfusion CVC line was always locked, and the manipulation associated

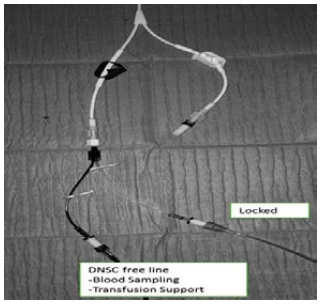


**Figure 4.** DSNC free line and procedures

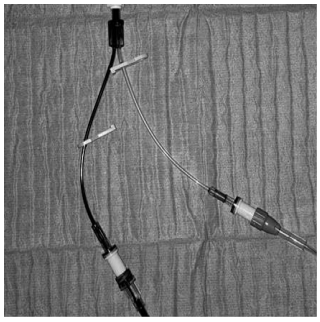

**Figure 5.** Tansparency Line

with the blood products sampling or administration was performed through the free DSNC line (far of the hub) (Figure 4). Haddadin & Regunath reported in their "CLABSI book" publication, that the intraluminal contamination of the hub is usually consequence of the health care provider´s contaminated hands, rarely from host and often from breach of standard aseptic precautions to access the CVC (Haddadin Y. & Regunath H., 2018). Furthermore, The Guidelines for the Prevention of Intravascular Catheter Related Infections in 2011 highlighted that the inadequate flushing of the device (due to poor visualization of the fluid flow pathway in opaque devices) and cellular deposits (especially consequence of the blood products sampling and transfusion support administration) could increase the infection risk related to the bacteria attached on the CVC. In these cases, the DSNC could improve a better observation regarding the transparency line (Figure 5) increasing the security procedure (associated with the view of blood products deposits) and making it possible with a more efficient CVC flushing. Considering that, the risk of catheter colonization (possible precursor of catheter related infection) could be affected. In fact, the study reported statistical differences in colonization rates, not influencing statistically the CLABSI rate distribution between groups. In this special population the infection source could be highly chargeable to the mucosal barrier microorganisms (Martinez JM, 2018) while the introduction of a new external device should not influence the reports.

### Scope and limitations

The clinical research related to neutropenia and CVC management in AL patients is scarce. The most important advantage of our study is that it was performed in a specific immunocompromised population with accurate infection control reports and CVC management programs. Several products could be found in the market to improve better clinical practice, however, in AL patients population the clinical research associated with their implementation and clinical used is scarce. The study tries to understand and explain how the DNSC can improve a better clinical practice in our department considering their performance and internal structure. The most important advantages of the DNSC were higher security and efficiency CVC procedures as shown in reports (blood sampling, transfusion support, multiple continuum perfusions...), on the other side, the superior elapsed time to prepare the materials to access the CVC could be considered a disadvantage. Taking into account the internal structure, the transparency line is really usefully to control the CVC maintenance procedures, and even considering the few opaque internal parts, the DNSC allows in the last case the substitution of the connector when the flushing seems not to be effective.

There's always an infection risk associated with all practices, products and populations. From start to end, the most important outcome that we can evaluate from this product is the colonization and catheter infection risk related. This study reports interesting results and theoretical arguments to support its implementation; however, more clinical research should be performed in this area to confirm the findings.

## Conclusion

This study suggests that the DSNC could be considered a good option for the nursing practice, aiming the reduction of the risk of central line colonization, improving a safer CVC management in AL patients undergoing high dose chemotherapy.

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