

Non-Infectious Complications of Non-Tunneled Central Venous Catheterization for Hemodialysis: Incidence and Reasons in Ouagadougou (Burkina Faso)

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Received 21 January 2016; accepted 25 March 2016; published 28 March 2016

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Abstract

Goal: Evaluate the importance and reasons of non-infectious complications of non-tunneled central venous catheterization in our hemodialysis unit. **Patients and methods:** The study, a prospective type, was conducted in the department of nephrology and hemodialysis of Yalgado Ouedraogo University Hospital Center (YO-UHC) in Ouagadougou, Burkina Faso, from 15 February to 30 June 2015. Patients in whom a new central venous catheter (CVC) was inserted during the study period were included. Catheterization-related complications were noted. **Results:** During the study period, 156 CVCs (9 per week) were placed in femoral (56.4%), internal jugular (40.4%) or subclavian vein (3.2%). There were 114 patients (59.7% of men and 40.3% of women), average age 41.8 ± 17.1 years, low socio-economic level in 64% of cases. At least a non-infectious complication was observed in 67 cases representing 42.9%. They were: puncture failure (40%), arterial puncture (12.2%), puncture of the thoracic duct (1.3%), pneumothorax (1.3%), bleeding related to the catheter insertion (5.8%), hematoma (1.3%), opposite direction (0.6%), dysfunction of the CVC (10.3%), femoral thrombophlebitis (3.2%). **Conclusion:** Non-infectious complications of non-tunneled central venous catheterization in our hemodialysis unit were frequent and sometimes severe. Their common denominator was the absence of ultrasound guidance. Our study reaffirms the need for equipping with Doppler ultrasound in our hemodialysis units, even in de-

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veloping countries, for better security of the patient during central venous catheterization.

Keywords

Burkina Faso, Catheterization, Complication, Hemodialysis, Pneumothorax, Thrombophlebitis

1. Introduction

The hemodialysis session requires access to the patient's blood. This access is possible via a central venous catheter (CVC) of hemodialysis inserted into a vein of sufficient gauge, or by an arterialized vein resulting from an arteriovenous fistula (AVF) created surgically. The CVC has the advantage over the AVF to be immediately usable. The prevalence of its use in western countries varies from 7% to 39% [1]. However, the use of CVCs is more often beset by complications of various natures. The infectious complication is the most common. The non-infectious complications are not rare and can be life-threatening for patients [2]. They are probably more common in the context of lack of equipment and/or human resources such as in the sub-Saharan African countries. Burkina Faso, a developing country, currently has a single functional hemodialysis unit. The prevalence of the use of CVCs is high because of the difficulty to create the AVFs for chronic hemodialysis. The CVCs available are short-lived and yet used for long periods of time in our unit. This would contribute to increase the frequency of non-infectious complications. In this study, we wanted to assess their importance and their reasons in our hemodialysis unit.

2. Patients and Methods

We conducted a short cross-sectional study in the department of nephrology and hemodialysis of Yalgado Ouedraogo University Hospital Center (YO-UHC) in Ouagadougou, Burkina Faso. It covered the period from 15 February to 30 June 2015.

The hemodialysis unit was opened in 2000. Its initial capacity of nine hemodialysis stations has been extended to 29 since 2009, for about 250 patients at the time of the study. The modality used is conventional hemodialysis. Patients are admitted to the unit for chronic hemodialysis in end-stage renal disease, or acute hemodialysis. Despite the insufficient capacity of the unit, there is still no official text governing access for patients to chronic hemodialysis.

The unit benefits a state subsidy. To enter the chronic hemodialysis program, the patient must pay a lump sum of about US \$840; CVC are given free. The acute hemodialysis costs about US \$25. Drug costs and diagnostic tests are entirely the responsibility of the patient. The majority of patients are from the city of Ouagadougou.

The CVCs insertion was performed by the physicians of the department (three seniors and two new physicians) in a room dedicated to this activity, but not equipped with ultrasound. The common anatomical landmarks are used for insertion. A chest x-ray face is performed after the insertion of a CVC at the neck. Maintenance of the CVC is explained to patients. It is removed at the end of use or in the case of complication.

The CVCs used at the time of the study were short-lived, made of polyurethane and tuneless. Their length was 15 or 20 cm. The CVC measuring 15 cm was preferentially inserted into the internal jugular or right subclavian veins; those measuring 20 cm were inserted into the internal jugular, left subclavian or femoral veins. The tunneled CVC was not yet available neither used in the unity. The unit did not have ultrasound.

The study population consisted of patients receiving chronic hemodialysis in the department of nephrology and hemodialysis unit of YO-UHC. Patients in whom a new catheter was inserted during the study period were included. We have not included cases where the CVC was changed based on recommendation.

We considered as complications the following:

- puncture failures;
- aberrant direction of the CVC;
- accidental punctures: arterial, of the thoracic duct (the puncture brings a milky liquid);
- pneumothorax: air in the pleural space. The diagnosis is suggested by a chest pain and respiratory discomfort. The diagnosis is confirmed by a chest x-ray and thoracentesis;
- thrombophlebitis on CVC: presence of thrombus on doppler study. Dysfunction of the CVC: no or insuffi-

cient blood flow;

- hemorrhage: unusual bleeding at the site of puncture;
- hematoma: painful swelling of the skin next to the site of puncture.

Sociodemographic, clinical and paraclinical data (the workup prior to the insertion of the CVC involved only new patients) were collected. Patients were followed from the CVC insertion to its removal.

Data were collected from the clinical examination of patients and the clinical record. A survey form was used to collect these data. The data have been processed on PC using the software Epi Info version 7.1.3.3. For the comparison of qualitative variables, Chi square and exact Fischer tests were used. The student's t test was used for comparison of quantitative variables. The level of statistical significance was set for a probability $p \leq 0.05$.

The consent of the patients (or their representative if they are unconscious) was obtained before their inclusion. They have been informed of the objectives and constraints of the study, and necessary monitoring measures. The study data were collected in the strict respect of anonymity and confidentiality. The YO-UHC lacked ethics committee at the time of the study.

3. Results

3.1. General Aspects

During the study period, 156 CVCs were placed representing approximately nine per week. These CVC insertion sites were diverse (**Table 1**).

114 patients were involved: 69 new patients (60.5%) for a first session of hemodialysis (acute or chronic) and 45 former patients already in chronic hemodialysis representing 39.5%. Among the 69 new patients, 20 patients representing 29% were in acute hemodialysis and 49 patients representing 71% in chronic hemodialysis. During the study period, 82 patients (71.9%) received a single CVC, 25 patients (21.9%) two CVCs, four patients (3.5%) three CVCs and three patients (2.7%) four CVCs.

The 114 patients included 68 men representing 59.7% and 46 women representing 40.3%. The sex ratio was 1.5. The average age of the patients was 41.8 ± 17.1 years (extreme = 5 and 85). It was 41.9 ± 17.1 years for men and 41.5 ± 17.3 years for women. There was no statistically significant difference for these two age groups ($p = 0.9$).

Seventy-three patients (64%) had a low socioeconomic level. The other patients had an average level (30 patients representing 26.3%) or high (11 representing 9.7%).

Personal history of patients is summarized in **Table 2**.

The total number of CVCs received before the study by 45 former patients in chronic hemodialysis was 153 representing an average of 3.4 ± 2.3 per patient.

When placing the CVC, 25 patients representing 16% were febrile and 30 patients representing 19.2% had dyspnea. In addition, we noted: edema of the lower limbs (62 patients representing 39.7%), global heart failure (17 cases representing 10.7%), right heart failure (4 cases representing 2.5%), comatose state (2 cases representing 1.3%). The mean arterial pressures were 148.6 ± 24.6 mm Hg (extreme = 70 - 218) and 89.8 ± 17.0

Table 1. Insertion sites of central venous catheters for hemodialysis.

	Number	Percentage
Femoral vein		
Right	59	37.8
Left	29	18.6
Total 1	88	56.4
Internal jugular vein		
Right	54	34.6
Left	9	5.8
Total 2	63	40.4
Subclavian Vein		
Right	4	2.6
Left	1	0.6
Total 3	5	3.2
Total	156	100

Table 2. Distribution of patients based on personal medical history.

Personal Medical History	Number	Percentage
Arterial Hypertension	62	54.4
Thrombophlebitis on Central Venous Catheter*	13	28.9
Diabetes	9	7.9
Gout	6	5.3
Human Immunodeficiency Virus Infection	3	2.6
AL Lambda Amyloidosis	1	0.9

*: The research was conducted in 45 chronic hemodialysis patients.

mm Hg (extreme = 40 and 125) respectively for the systolic and diastolic blood pressures.

The paraclinical workup prior to insertion of the CVC was done for 69 new patients. The average serum creatinine before hemodialysis was 2364.8 ± 1073.8 $\mu\text{mol/L}$ (**Table 3**).

3.2. Non-Infectious Complications

At least a non-infectious complication was observed in 67 cases representing 42.9%.

3.2.1. Puncture Failure

The global rate of puncture failure was 40%. The average number of punctures in the CVC insertion vein was 1.8 ± 1.4 per patient (extreme = 1 and 8). It was 1.6 ± 1.1 (extreme = 1 and 6) for men and 2 ± 1.7 (extreme = 1 and 8) for women. The difference between the gender was not statistically significant ($p = 0.1$). The average number of punctures of the vein did not vary significantly according to the CVC insertion site (**Table 4**).

One hundred-thirty-nine CVCs representing 89.1% were inserted without change of site. In the 17 remaining cases, the change of insertion site was motivated by:

- no progression of the guide: five CVCs representing 29.4%;
- iterative arterial puncture: seven CVCs representing 41.2%;
- difficulty in tracking the vein: five CVCs representing 29.4%.

3.2.2. Puncture Accidents

An arterial puncture was observed during the insertion of 19 CVCs representing 12.2 percent of the 156 CVCs. The affected artery was the femoral (11 cases representing 12.5% of the 88 femoral CVCs) or the right carotid artery (8 cases representing 12.7% of the 63 internal jugular CVCs).

The thoracic duct was punctured during insertion of two CVCs in the right internal jugular vein representing 1.3% of the 156 CVCs. A pneumothorax was observed during insertion of two CVCs in the right internal jugular vein representing 1.3% of the 156 CVCs and 3.2% of the 63 jugular CVCs.

3.2.3. Hemorrhage

A hemorrhage through the insertion hole of the CVC was observed after insertion of nine CVCs representing 5.8% of 156 CVCs. It concerned the femoral vein in 8 cases representing 9.1% of 88 CVCs inserted into the femoral vein and the jugular vein in one case representing 1.6% of 63 CVCs inserted into the internal jugular vein. A hematoma was observed when inserting two CVCs in the internal jugular vein, representing 3.2% of jugular CVCs.

3.2.4. Insertion Path Accident

One CVC representing 0.6% has taken the wrong direction into the right internal jugular vein while attempting to insert it into the right subclavian vein. This path has been favored by the presence of a large thrombus (as seen on the subsequent Doppler) into the right subclavian vein just downstream of the right subclavian-jugular venous confluence (**Figure 1**).

Table 3. Results of laboratory tests in 69 new patients on hemodialysis.

	n (%)	m ± SD	Extreme
Serum Creatinine (μmol/L)	69 (100)	2364.8 ± 1073.8	444 - 5868
Azotemia (mmol/L)	69 (100)	38.1 ± 16.1	10.4 - 99.8
CRP (mg/L)	13 (18.8)	89.9 ± 143.7	0.2 - 479
Hemoglobin (g/dL)	69 (100)	7.3 ± 1.5	3.7 - 11.7
Leukocytes (éléments/mm ³)	69 (100)	8612.8 ± 6735.5	1200 - 39100
Platelets (éléments/mm ³)	69 (100)	238126.1 ± 147420.1	20000 - 927000

CRP: C Reactiv Protein; m: mean; n: number of patients who completed the biological examination; SD: standard deviation.

Table 4. Average number of punctures according to the insertion site of the central venous catheter.

Insertion Site of the Catheter	m ± SD	Extreme
Femoral Vein	1.9 ± 1.6	1 et 8
Internal Jugular vein	1.6 ± 1.1	1 et 5
Subclavian vein	2.6 ± 1.5	1 et 5

m ± SD: mean ± standard deviation; p = 0.3.

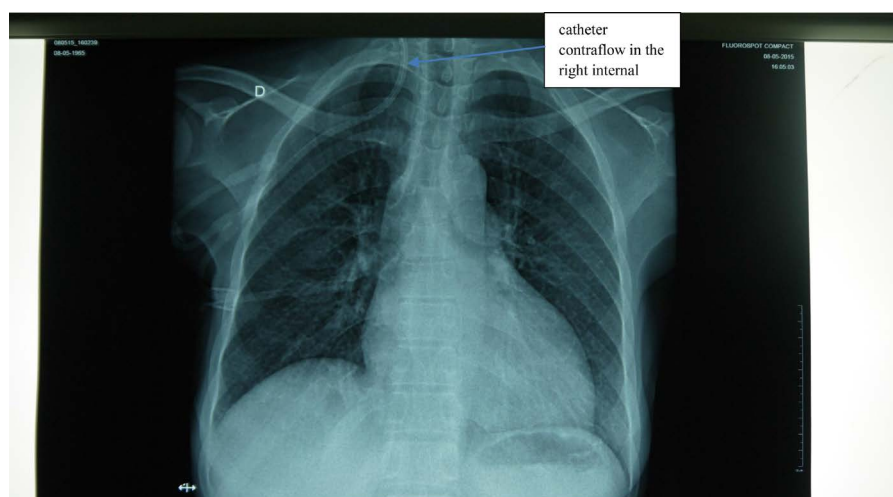


Figure 1. Aberrant course of a central venous catheter for hemodialysis inserted in the right subclavian vein, diverted contraflow in right internal jugular vein due to thrombosis of the right jugular-carotid confluence.

3.2.5. Dysfunctions of the CVC

The dysfunction of the CVC was observed in 16 cases representing 10.3%. It involved 13 femoral CVCs representing 14.8% of femoral CVCs, three jugular CVCs representing 4.8% of internal jugular CVCs. The dysfunction was precocious in three cases and caused by an intraluminal thrombosis (one case), a wrong direction (one case); and undetermined in the third case. In 13 cases, the dysfunction was late. It concerned the CVCs inserted in femoral vein in 11 cases. It was due to an intraluminal thrombosis of the CVC (seven cases), a bending of the CVC (one case) and a thrombophlebitis on CVC (five cases).

3.2.6. Thrombophlebitis on CVC

There were five thrombophlebitis on CVC representing 3.2% of 156 CVCs. The CVCs in question were all inserted into a femoral vein. Four women and one man were involved. The average duration of use of these CVCs

was 26.8 ± 24.1 days (extreme = 9 and 67) vs 26 ± 28.4 days (extreme = 0 - 122) for the femoral CVCs without thrombophlebitis.

4. Discussion

Our study took place in a context of limited resources. As such, the means were not always available to enable good practices according to international recommendations on catheterization for hemodialysis. Nevertheless, our study has the merit of showing the reality of our hemodialysis unit; providing results that are reliable and could serve us for the improvement of our hemodialysis patients' care.

Our study population was young; the average age was 41.8 ± 17.1 years, as in most of the developing countries [3] [4]. In developed countries, patients are much older with an average age above 62 years [5] [6] at the initiation of the treatment by hemodialysis.

The majority of our patients had a low socioeconomic level (64%). It fits in the context of general poverty in Burkina Faso, ranked 181 among 187 countries with a low human development index (0.388) [7]. The prevalence of diabetes of 7.9% in our sample was low compared to the results reported by some authors in developing countries where it may reach 41% [8]. Our patients, with their young age and low frequency of comorbidities such as diabetes, should in principle have a better vascular condition than those of developed countries.

The activity of CVC insertion was very important in our hemodialysis unit. In fact, about nine CVCs were inserted per week. The 45 chronic hemodialysis patients received an average three CVCs by patient. This is explained by the very frequent use of temporary CVCs due to a long delay for making AVFs or lack of possibilities to repair them. This long delay was related to the lack of surgeon availability and financial means for a significant proportion of patients.

The CDC (Center of Diseases Control) and KDOQI [9] [10] recommendations have not always been respected in the case of chronic hemodialysis. Indeed, the most used vein was the femoral vein (50.7%) then the internal jugular vein (45.5%) and the subclavian vein (3.8%). However, our results are comparable to those reported by Sanogo [11] in Mali where the CVC insertion sites, in order of frequency, were the femoral veins (53.8%) and internal jugular vein (44.6%). In our serie, the high frequency of CVCs insertion in femoral veins for chronic hemodialysis due to various reasons: high proportion of patients with orthopnea (19.2%) therefore cannot withstand the supine position, lack of appropriate CVC lengths and mastery of CVC insertion into jugular veins by junior doctors at the time of the study.

Regarding acute hemodialysis, the recommendations of learned societies have been met. Thus, the femoral vein was used first (87.5%). No CVC has been inserted into the subclavian vein. The reasons given for the cases of chronic hemodialysis patients reveal the poor care conditions in our country: hemodialysis session every four days, lack of compliance of some patients to the salt and water restriction, bad control of pressure sometimes due to a therapeutic rupture related to lack of financial means.

The change of the site of insertion was observed with 10.9% of CVCs. The main reasons were the non-progression of the CVC guide (41.2%), iterative arterial punctures (29.4%) and the difficulty of locating the insertion vein (29.5%). These reasons are mainly related to the lack of use of ultrasound guidance. Thus, one could for example avoid unnecessary punctures in the cases of stenosis and thrombosis that could have been revealed by a previous Doppler ultrasound. The lack of operator change in case of iterative puncture failures should not be overlooked. During our study, the change of operator for the same patient was only after multiple puncture failures or puncture failure after changing site. However, the risk of accidental arterial puncture is associated with the increased number of percutaneous puncture [12] [13]. Therefore, authors such as Mason and al. [14] recommend changing operator after two unsuccessful punctures, and three for Laksiri *et al.* [15]. The change of operator in our context is not always obvious because of the small number of the medical staff compared to the workload in the department of nephrology and hemodialysis. Thus, the difficulty of changing operator (because of reduced medical staff) and the absence of ultrasound guidance have contributed to the high rate of failures and puncture site change.

Table 5 compares mechanical complications of our series with those of other authors.

In our context, the high incidence of complications mentioned in **Table 5** is directly related to the blind insertion technique of the CVC. Our department did not have an ultrasound at the time of the study. The blind insertion technique uses anatomical landmarks assumed to be fixed, which is not always the case. Indeed, the anatomical variants of internal jugular and the femoral veins are seen in more than 15% of cases [17]. The ultra-

Table 5. Frequency of mechanical complications reported by various authors according to the insertion site of the central venous catheter.

	Internal Jugular (%)	Subclavian (%)	Femoral (%)
Arterial Puncture			
McGee*	6.3 - 9.4	3.1 - 4.9	9 - 15
Iovino [16]	1	2.7	-
Our serie	12.7	0	12.5
Pneumothorax			
McGee*	<0.1 - 0.2	1.5 - 3.1	NA
Iovino [16]	0	3.1	NA
Our serie	3.2	0	NA
Hematoma			
McGee*	<0.1 - 2.2	1.5 - 3.1	3.8 - 4.4
Iovino [16]	-	-	-
Our serie	3.2	0	0

*: Data of several authors reported by McGee *et al.* [12]; NA: not applicable.

sound guidance, in agreement with the current international recommendations, is considered as the technique of reference for the insertion of CVCs [18]. The ultrasound, by guiding the puncture into the vein and detecting anatomical variations, improves the success rate and comfort, and decreases the insertion time, the number of punctures, the number of complications and the cost [19] [20]. This could also help reduce the risk of being sued to which any operator may be exposed [21].

A case of CVC in the wrong direction in the right internal jugular vein was observed. The incident occurred in a patient who had previously received several CVCs (two in the right subclavian vein and three in the right internal jugular vein). The Doppler has highlighted a large thrombus just downstream of the jugular-right subclavian confluence. Few similar cases were reported. Merrer *et al.* [14] in his comparative study of subclavian and femoral sites had observed 5.6% of path errors among the CVCs inserted into the subclavian vein. Such a path could seriously disrupt the cerebral hemodynamics. Once again, the lack of ultrasound guidance was a factor favoring a non-infectious complication.

In our study, CVC dysfunctions were observed in 16 cases. They involved the femoral site in 13 cases representing 81.3%, but 14.8% of femoral CVCs. A prospective randomized study compared the femoral and internal jugular sites in terms of dysfunction of the CVC. It was found that the femoral and jugular sites were equivalent in terms of dysfunction of CVCs, subject to the use of a CVC adapted to the specificities of the femoral route (length 24 cm). However, the left internal jugular exposes to a higher risk of dysfunction compared to the femoral and right internal jugular approach [22]. In our study, the femoral site was the mostly used, which may explain its predominance in the dysfunction frequency. If our jugular CVCs were tunneled, that would have further reduced the risk of dysfunction in jugular site [23]. So we can remember that the nature of the CVC that we used intervened in the high frequency of observed dysfunctions.

The use of a CVC very frequently leads to the formation of a fibrous sheath in the vein where the CVC is placed. The thromboses arising the reform are very often asymptomatic. For these reasons, they are undervalued. During the study of Timsit and al on 208 CVCs, the Doppler of the catheterized sites has highlighted a thrombosis in 42% of cases but it was occlusive in only 3% of cases [24]. A postmortem study on 72 patients done by Raad *et al.* [25] found a mural thrombosis at the level of the catheterized vein in 38% of cases and right atrial mural thrombosis in 5.6% of cases.

The incidence rate of thrombosis is variable according to the CVC insertion site. The jugular and femoral sites are more thrombogenic than the subclavian sites [12]. In our study, a thrombophlebitis on CVC was observed in five patients who had their CVC on the femoral site. We did not find a relationship between the formation of a thrombosis and the development of an infection related to the CVC. The femoral site seems to be the main factor favoring venous thrombosis in our series.

5. Conclusion

Non-infectious complications of non-tunneled central venous catheterization were frequent in our series. Some

are potentially serious because that may, directly or not, be life-threatening. The main reason for these complications was the absence of ultrasound guidance due to insufficient equipment in our hemodialysis unit. Some aspects not less important as the deficiency in qualified human resources have contributed to this high frequency. Thus, our study reaffirms the need for an ultrasound-Doppler in hemodialysis units, even in developing countries, for a better patient safety and better legal coverage of the doctor performing the catheterization.

Conflicts of interest

The authors have no conflicts of interest to declare.

Acknowledgements

The authors thank Dr. Manan Hien for translating the text into English.

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