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DAMAGE OF CENTRAL CATHETERS IN HOME PARENTERAL NUTRITION PATIENTS

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According to the ESPEN and ASPEN guidelines, in the case of a long-term (>3-month) parenteral nutrition should be administered via a subcutaneous central venous catheter (CVC). There are three types of mechanical complications of tunnelled central catheter: catheter rupture, occlusion by TPN depositing and thrombofibrotic occlusion.
The aim of the study was to analyse the incidence of complications central catheter in a group of patients receiving HPN.
Material and methods. Between January 2010 and June 2014, HPN was conducted in 584 patients (306 women and 278 men), ninety-nine patients were enrolled in the study: 67 women and 32 men in whom mechanical complications of central catheters were found.
Results. Among 99 patients, 71 used the tunnelled Broviac catheter. Groshong catheters were placed only in patients receiving parenteral nutrition due to cancer. Analyses have shown differences between the older and younger in the number of mechanical complications. Younger patients were found to have a larger number of catheter complications (1.6 ± 1.1) in comparison with older patients (1.3 ± 0.7). The catheter that was most commonly damaged was the Broviac catheter 76.8%. The most frequent type of mechanical complications was catheter rupture 64.81%.
Conclusions. Mechanical complications of tunnelled central catheters in HPN patients can be repaired in an outpatient setting in half of the cases, which enables continuation of parenteral nutrition without the need to hospitalise the patient. The centres that conduct HPN should offer 24-hour care and help in case of problems with the central venous line to the patients.
Key words: HPN, CVC

Parenteral nutrition is a method of delivering nutrients in patients with dysfunctional gastrointestinal tract. It can be conducted over a short-term period in a hospital setting or a long-term period in the home setting in patients requiring such type of treatment. According to the ESPEN and ASPEN (European /American Society of Parenteral and Enteral Nutrition) guidelines, in the case of a long-term (>3-month) parenteral nutrition should be administered via a central venous catheter (CVC). Long-term parenteral nutrition requires the use of totally implantable subcutaneous port systems or tunnelled CVCs: e.g. Broviac, Broviac Expert, Groshong (1). The choice between a tunnelled catheter and a totally implantable port depends on a number of factors: the preferences and experience of the parenteral nutrition team, the patient's decision and consent, and the required frequency of venous access (2, 3, 4). Complications associated with home parenteral nutrition (HPN) can be divided into metabolic, mechanical, and septic (5, 6).

The most common access in long-term parenteral nutrition is a tunnelled catheter made of polyurethane or silicone. Tunnelling is a term that describes placing the extravascular

part of the central catheter in a tunnel created in the subcutaneous tissue, between the point of entry in the central vein and the site of catheter insertion (7). The purposes of subcutaneous tunnelling are:

– to prevent septic complications by limiting bacterial migration along the outer surface of the catheter into the bloodstream,
– to facilitate the care of the catheter insertion site,
– to enable the patient to self-handle the central venous line.

Tunnelled central catheters have a reinforced external part consisting of a thicker silicone sleeve and a Dacron cuff placed on the catheter inside the subcutaneous tunnel. The Dacron cuff, commonly known as "the muff", enables the proliferation of fibrous tissue around the catheter and ensures catheter stabilisation in the subcutaneous tunnel. The cuff performs an additional role of a mechanical and bacteriological barrier against migration of microorganisms from the insertion site to the central catheter tunnel. Some catheter types are additionally equipped with a second muff made of collagen impregnated with silver ions, which creates a chemical barrier against microorganisms and infection.

In tunnelled central catheters, to limit the development of septic complications of the subcutaneous tunnel, chlorhexidine is used, which coats the whole length of the external and internal surfaces of the catheter. Moreover, catheters coated with silver ions on their external and internal surfaces are available. Such a coating ensures long-term antibacterial activity, throughout a long period of silver ion release. Most central catheters used in long-term nutrition are single-channel catheters with a single opening. Moreover, multi-channel catheters with additional external openings are available, called multi-lumen catheters. Large-lumen catheters, referred to as multi-channel catheters, are used in chronic parenteral nutrition when it is necessary to administer by continuous infusion other additional fluids that are not compatible with the nutrition bag, e.g. in patients who require concomitant chemotherapy. The same applies to vascular ports, which are most commonly implanted in cancer patients for the delivery of chemotherapy and then, if necessary, may be used for infusing parenteral nutrition formulas.

Types of complications of central catheters in HPN patients

– Catheter rupture. It occurs mostly above the catheter hub, at the place where the clip is located. Catheter may rupture in the course of attempts to unblock a clogged catheter, when, as a result of a flushing attempt with creation of a high pressure in the catheter, its internal wall ruptures and liquid penetrates between the two layers of the catheter. Catheter expands in a balloon-like fashion in its external part, which is accompanied by an unnatural bulge which is often absorbed after a few minutes. Catheter rupture is an indication for removal of a non-tunnelled catheter, while in the case of tunnelled catheters, if no infection symptoms are present, an effective attempt can be made to repair the catheter by replacing its tip with a new one. Repair kits dedicated by the manufacturer are intended for such repairs.

– Occlusion of a catheter lumen by TPN depositing. It represents 25-40% of complications associated with catheter maintenance. Occlusion may be caused by fibrin deposits around the catheter lumen, forming a "valve" that prevents aspiration of blood through the catheter but at the same time does not interfere with fluid delivery and catheter flushing. In patients receiving chronic home parenteral nutrition, the most common cause of catheter occlusion are lipid-electrolyte-protein masses depositing in the central catheter hub and lumen.

– Thrombofibrotic occlusion. It may occur at any time after catheterisation, during the whole period the catheter is present in the central vein. A common cause of occlusion is clogging with a thrombus formed as a result of venous blood backflow into the central catheter lumen. The mechanisms responsible for blood backflow into the vessel lumen are most commonly leaking of the venous line, improper techniques of closing the catheter for the break time, catheter rupture or using inappropriate stoppers to close the catheter. In the mechanism of fibrinogenesis, the fibrin coat accumulating on the catheter surface may clog the catheter lumen or travel below the catheter, forming a fibrin "tail", which interferes with blood aspiration or infusion of nutrition bag contents but has no effect on circulation in central veins. Another form of this complica-

tion are parietal thrombi developing along the venous vessel wall, impairing blood flow in the central vein and preventing delivery of the nutritional formula through the central catheter.

The aim of the present study was to analyse the incidence of complications of central catheters in a group of patients receiving home parenteral nutrition.

MATERIAL AND METHODS

Between January 2010 and June 2014, home parenteral nutrition was conducted in 584 patients (306 women and 278 men). In the above period, parenteral nutrition in patients was delivered through the following types of central catheters:

- Broviac catheter – in 341 patients (169 women and 172 men),
- Broviac Expert catheter – 157 patients (63 women and 94 men),
- Groshong catheter – 74 patients (65 women and 9 men),
- vascular ports and non-tunnelled catheters – 12 patients (9 women and 3 men).

Ninety-nine patients receiving home parenteral nutrition were enrolled in the study, including 67 (67.7%) women and 32 (32.3%) men in whom mechanical complications of central catheters were found. The mean age for the study population was 59 years (±15.3). The analysed group of patients received HPN due to the following causes:

- neoplastic obstruction – 14,
- inflammatory diseases of the intestines – 9,
- short bowel syndrome – 76.

Statistical analysis

The IBM SPSS software, version 21 for Windows, was used for statistical analyses. Statistical calculations were performed with the use of the T-Student test, U-Mann-Whitney test and Pearson's correlation coefficient r.

Procedures performed

Repair of the central catheter

In each case, before an attempt to repair the catheter was made, blood was collected from the catheter for culture. Most of mechanical damage repairs were performed immediately after blood was collected from the damaged central catheter for culture. If the central catheter wall was damaged more than 24 hours earlier, the repair operation was performed only after a negative result of blood culture from the central catheter was obtained. If it was impossible to collect blood due to occlusion of the external tip of the central catheter lumen, a fragment of the occluded catheter was cut off, blood was collected for culture directly from the "catheter stump", the clamp was closed on the catheter and, finally, the catheter was secured with a sterile pack until the results of blood culture from the central catheter stump were obtained.

After confirmation of the negative result of culture of the blood or washings from the "central catheter stump", the central catheter was repaired with the use of the special kit provided by the catheter manufacturer. If a positive result of blood culture from the "central catheter stump" was obtained, the catheter was removed, targeted antibiotic treatment was instituted, and a few days later a new central catheter was placed. Central catheters were repaired when the catheter hub cracked, the catheter was leaking or the catheter was clogged – when a bulge on the catheter was visible. Only ready-made repair kits were used for repairs. The duration of the procedure was 60 minutes.

Restoring patency of a clogged central catheter

If the catheter became clogged with sediments originating from the nutritional formula, the catheter hub and then the internal walls of the catheter were thoroughly cleaned. Restoring patency involved filling the catheter with 95% ethyl alcohol in a volume corresponding to the internal volume of the catheter (approximately 0.8 ml) and leaving that solution in the central catheter for 2 hours. All those operations must be performed aseptically, the alcohol solution should be withdrawn into the syringe through a 0.22 micron antibacterial disc filter, and then administered into the central catheter. Two hours after filling the central catheter with alcohol, a test of aspiration of the deposit in the catheter must be performed, and the catheter as well as the hub must be washed with normal

saline solution. If the catheter is not sufficiently patent, the procedure of filling the catheter with alcohol must be repeated. If an attempt to restore patency is unsuccessful, removing off the catheter and placing a new tunnelled central line must be considered. In the case of thrombofibrotic complications, administration of recombinant tissue plasminogen activator (rTPA) into the catheter is allowable. The duration of a single procedure of restoring catheter patency is 60-180 minutes.

Removal of the central catheter

Common causes of catheter removal include mechanical complications associated with long-term catheter use such as catheter occlusion, cracking of the catheter hub causing leakage of the venous line, and catheter tearing. Another reason for catheter removal may be previous multiple repairs which make the subsequent repair impossible in view of technical non-feasibility of another repair with the use of the repair kit dedicated by the manufacturer. Other reasons for catheter removal are: catheter infection, phlegmon of the catheter tunnel or phlegmon of the port. Central catheters are removed using a strict antiseptic technique, under short-term topical anaesthesia. The duration of catheter removal is about 15 minutes.

Placement of a new tunnelled central catheter

The procedure is preceded by hygienic preparation of the patient by removing hair from the skin at the central catheter implantation site and thoroughly washing the skin with antiseptics twice, with an interval of a few hours. The tunnelled central line is always placed in an operating theatre setting, under local anaesthesia and under fluoroscope or ultrasound guidance. The duration of the procedure is approximately 60 minutes.

RESULTS

Number of defects of the central catheter in function of patient age: analyses with the use of non-parametric U-Mann-Whitney test have shown existing differences (at a trend level) between the older and younger in the number of mechanical complications of the catheter, U=564.5; p=0.05. Younger subjects were found to have a larger number of catheter defects (1.6 ± 1.1) in comparison with older patients (1.3 ± 0.7).

Mean age of patients and duration of parenteral nutrition in function of the tunnelled central catheter type: the oldest patient group consisted of persons with the Groshong catheter. The detailed results are presented in tab. 1.

Breakdown of patients by catheter type: Among 99 study subjects, 71 (71.72%) used the tunnelled Broviac catheter. Groshong catheters were placed only in patients receiving parenteral nutrition due to cancer. The detailed results are presented in tab. 2.

Number of mechanical defects of the central catheter in function of patient sex: There was a trend towards differences between women and men in the number of central catheter defects t (73.9)=1.76; p=0.09. Women appear to experience more catheter complications (1.6 ± 1) than men (1.3 ± 0.6). Type of central catheter placed in function of patient sex: Both in women and in men, the most popular type of catheter placed was the Broviac catheter. The detailed data are presented in tab. 3.

Table 1. Mean age of patients and mean duration of parenteral nutrition in function of the catheter type

Catheter type		Average age the patient (age)	The average time of HPN (age)
Groshong	M	66,57	6,36
	SD	16,48	3,99
Broviac	M	57,85	8,83
	SD	15,01	4,80
Broviac Expert	M	60,79	5,57
	SD	14,41	4,79

Table 2. Type of central catheters which were damaged in the analysed group of patients

Catheter type	Number of patients	% of patients
Groshong	14	14,14
Broviac	71	71,72
Broviac Expert	14	14,14
% of patients	99	100

Table 3. Summary of the numbers of catheters broken down by sex, with percentages

Catheter type	Women		Men	
	number of central catheter	% of patients	number of central catheter	% of patients
Groshong	13	19,4%	1	3,13%
Broviac	46	68,66%	25	78,13%
Broviac Expert	8	11,94%	6	18,75%
All catherers	67	100%	32	100%

Type of complication of the central catheter depending on the central catheter type

The most frequent type of mechanical defect was catheter rupture, n-70. The total number of all complications was 108. The catheter that was most commonly damaged was the Broviac catheter (n=76.8%). The detailed data are presented in tab. 4.

Type of complications to the central catheter and the actions taken

The detailed data on the types and frequency of mechanical complications of a tunnelled central catheter and on the methods of dealing with each complication are presented in tab. 5.

Type of complication in function of the duration of parenteral nutrition

The patients were divided into two groups by duration of their parenteral nutrition: patients with short-term HPN: up to 4 years (±1.8), and patients with long-term HPN: up to 12 years (±4.2). As demonstrated by the comparative analysis, the longer the duration of use of the tunnelled central catheter, the higher the number of mechanical complications. Results are presented in tab. 6.

DISCUSSION

One of first decisions after the patient is found eligible for the HPN procedure is planning the appropriate vascular access. The issues of selection of the intravenous entry site and of conduct of a high quality procedure of central line placement are well known and described (8, 9). Medical centres that undertake the conduct of home parenteral nutrition must possess knowledge in prophylaxis and dealing with mechanical complications of tunnelled central catheters. If a mechanical complication occurs, the personnel of the given HPN centre should have specific and validated procedures for handling the patient and the

Table 4. Summary of causes of catheter defects broken down by frequency of complications for each catheter type

Type of complication	Number of complications	Groshong	Broviac	Broviac Expert	Total of complications
Occlusion by TPN depositing	1 x	-	8	1	24 (22,2%)
	2 x	1	4	1	
	3 x	-	1	-	
Catheter rupture	1 x	5	34	10	70 (64,8%)
	2 x	-	8	1	
	3 x	-	1	-	
Thrombofibrotic occlusion	1 x	1	2	-	7 (6,5%)
	2 x	-	-	-	
	3 x	-	-	-	
	4 x	-	1	-	
Accidental extraction of the catheter	1 x	1	3	1	7 (6,5%)
	2 x	0	1	0	
Total of damage per catheter		9 (8,4%)	83 (76,8%)	16 (14,8%)	108 (100%)

Table 5. Type of damage to the central catheter and the actions taken

Type of complication	Number of complications	Repair of the central catheter	Replacement of the catheter	Total of complications
Occlusion by TPN depositing	1 x	3	10	24 (22,23%)
	2 x		4	
	3 x		1	
Catheter rupture	1 x	30	25	70 (64,81%)
	2 x	6		
	3 x	1		
Yhrombofibrotic occlusion	1 x	1	3	7 (6,48%)
	2 x			
	3 x	1		
Accidental extraction of the catheter	1 x		5	7 (6,48%)
	2 x		1	
Total of the procedure		52 (48%)	56 (52%)	108 (100%)

Table 6. Types of complications in function of the duration of parenteral nutrition

Type of complication	Number of complications	Short-term HPN	Long-term HPN	Total of complications
Occlusion by TPN depositing	1 x	5	4	24 (22,23%)
	2 x	5	1	
	3 x		1	
Catheter rupture	1 x	24	25	70 (64,81%)
	2 x	3	6	
	3 x		1	
Thrombofibrotic occlusion Accidental extraction of the catheter	1 x	1	2	7 (6,48%)
	2 x			
	3 x			
	4 x		1	
	1 x	3	2	7 (6,48%)
	2 x	1		
Total of complications		51 (47,2%)	57 (52,8%)	108 (100%)

damaged tunnelled central catheter. In the HPN procedure, in patients with dysfunctional gastrointestinal tract, every effort should be used to keep the tunnelled central catheter in place as it is often the only route of nutrient delivery. Proper and careful handling of the central catheter makes it possible to minimise some mechanical complications, which include damage to the central catheter hub, rupture of the catheter cuff, occlusion, etc. (10). To minimise the number of complications, the patient and the patient's caregiver must undergo detailed training in the handling of the central tunnelled venous line. The patient and the patient's caregiver must be informed that persons who are not trained in line handling put the patient at risk of the development of mechanical and septic complications which are life-threatening for the patient. Training the patient or the patient's caregiver by the qualified nursing personnel dealing with the above issues on a daily basis is very important in the prevention of complications in home parenteral nutrition (11, 12). The developed procedures for the prevention of mechanical complications and routine methods of handling an existing mechanical complication minimise the need to replace the patient's central catheter and to expose the patient to the stress related to hospitalisation and potential complications. Patients receiving chronic parenteral nutrition are at an increased risk of thrombotic complications, which limit the possibility of placing a new

central catheter and may be an additional cause of other serious iatrogenic mechanical complications which include pneumoperitoneum, haematoma, perforations of venous vessels (13, 14). The prevention of parenteral nutrition complications and their outpatient treatment without the need for hospitalisation are important factors limiting the financial costs borne by the hospital in the case of conducting the HPN procedure.

In conducting HPN via a central catheter, a common problem is blood backflow and clotting in the catheter lumen, which ultimately leads to occlusion of the central catheter. From our experience, one of the causes of blood backflow into the lumen of a tunnelled central catheter seems to be bad quality of the stoppers with a rubber membrane used for closing the central catheter hub. If these elements are of poor quality, there is a risk of blood backflow into the catheter lumen and causing occlusion of the central catheter. For many years, attempts have been made to prevent thrombotic complications by filling the central catheter channel with heparin solutions (15).

However, in the recent years numerous reports appeared that questioned the need for flushing the central catheter with heparin solutions. There is no conclusive evidence proving the efficacy of flushing catheters with heparin in comparison with other solutions such as normal saline or urokinase in lowering the frequency of central catheter thrombosis (16, 17, 18). Another non-patient-related HPN complication is catheter clogging with amorphous masses formed as a result of precipitation of the ingredients of the nutrition bag contents. According to reports in the scientific literature, one of the causes of parenteral nutrition ingredient precipitation is the use of heparin for flushing central catheters. The responsible mechanisms are most probably physicochemical incompatibility of the TPN formula with a fat emulsion ingredient, and the use of heparin for flushing the central catheter (19, 20). Incompatibilities between heparin and the AIO formula, even at low concentrations of heparin sodium, cause catheter clogging and an increased frequency of infections with the resulting need to remove the catheter (21).

Moreover, our experience indicates that the use of Omegaven 10% lipid emulsions contributes to increased deposition of amorphous material in the catheter lumen in comparison with other lipid emulsions. After two months of use of such lipid emulsions, regardless of the type of central catheter placed, most patients complained about problems with nutritional formula flow, and even complete occlusion of the catheter lumen and hub. Those patients required more frequent procedures of catheter patency restoration and replacement of the central catheter hub. A partial solution to this problem seems to be the use of special pumps for the delivery of parenteral nutrition by the HPN patients. These pumps force the delivery of the HPN bag content regardless of gravity, which considerably limits the formation of amorphous (electrolyte-protein-fat aggregates) clogging the catheter lumen (5). An interesting question arising from the results obtained is why mechanical damage to tunnelled central catheters occurs more commonly in women. Perhaps this may be attributed to differences in the anatomical structure of the chest between women and men. In women it is not always possible to optimally place the external exit of the central catheter onto the skin, so as it does not get tangled in the underwear. Before central catheter placement, the site of catheter insertion must be planned with the patient in the standing and lying positions, so that to make it the most optimal and easy to self-handle.

The results obtained prove that most cases of mechanical damage occur in younger patients. This seems to be associated with less care when handling central catheters and also with haste when connecting the nutritional formula.

In the medical literature, there is very little information about mechanical complications of tunnelled central catheters designed for HPN. Most of the articles apply to septic complications and treatment of catheter-induced blood infections. The issues of mechanical complications of tunnelled central catheters seem to be marginalised. It should be noted that there has been an increasing number of chronic home parenteral nutrition centres, which do not have systematic knowledge or experience. Scientific societies dealing with nutritional treatment should issue joint recommendations for the methods of handling such mechanical defects of central catheters in order to improve the safety and quality of HPN.

CONCLUSIONS

Mechanical complications of central tunellized catheters in HPN patients can be repaired in an outpatient setting in half of the cases, which enables continuation of parenteral nutrition without the need to hospitalise the patient. While HPN procedure it should be borne in mind that an increasing number of catheter lumen patency restoration procedures in an outpatient setting is associated with an increasing need to replace the central catheter hub and even to place a new tunnelled central catheter. The medical centres that conduct HPN should offer 24-hour care and help in case of problems with the central venous line to the patients.

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