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THE ROLE OF ANTIBACTERIAL CONTROL IN THE STRATEGY OF PROLONGED REGIONAL ANESTHESIA: A PROSPECTIVE, OPEN-LABEL, COMPARATIVE, SINGLE-CENTER STUDY

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Abstract. Catheterization for prolonged regional anesthesia brings about potential conditions for the development of infectious complications. The frequency of their occurrence is low, but, in case of occurrence, it can lead to serious consequences for the patient, as well as increase the duration of stay in the hospital. Colonization of the catheter with microflora in the amount of 10^5 CFU or more means that there is a risk of developing an infectious complication. ***Objectives.*** To determine the strategy of regional anesthesia based on data for catheter colonization depending on the method of its fixation and duration of use, as well as to determine the prevailing type of microflora inoculated. ***Materials and methods.*** A prospective, open, comparative, single-center study included 87 patients aged 2 to 18 years. All patients underwent prolonged regional anesthesia, and depending on the method of fixing the catheter were divided into 3 groups — in the first group catheter was fixed with an adhesive sticker (AS), in the second — an adhesive sticker used with the antimicrobial coating Desitol V (AS + D), in the third catheter tunneling (T) was applied. Bacteriological study of microbial contamination was carried out in the classical way. ***Results.*** None of the 87 patients had signs of a local or systemic infection. The difference in the frequency of colonization between the FN and FT groups was statistically significant: χ^2 (1,N = 65) = 6.45 (p = 0,011), between the FN and FN + D groups it was not significant. The relative risk of colonization of the skin part of the catheter when fixing with a sticker is 2.25 times higher than when tunneling the catheter: RR = 2.25 (p = 0.05) (95% CI 1.069–4.73). In the FN + D group, colonization of both the skin and the inner part of the catheter was noted at significantly earlier periods than in the PT group: skin part: U = 6,5; Ucr = 10; p = 0,018; inner part: U = 6; Ucr = 6; p = 0,047. With positive results of bacterial analysis, the culture of *St. epidermidis* (48,3%) and *St. aureus* (19,3%). ***Conclusion.*** When planning postoperative analgesia lasting 3 days and more, tunneling is the preferred method of catheter fixation.

Key words: regional anesthesia; catheterization; infectious complications.

РОЛЬ АНТИБАКТЕРИАЛЬНОГО КОНТРОЛЯ В СТРАТЕГИИ ПРОДЛЕННОЙ РЕГИОНАРНОЙ АНЕСТЕЗИИ: ПРОСПЕКТИВНОЕ, ОТКРЫТОЕ, СРАВНИТЕЛЬНОЕ, ОДНОЦЕНТРОВОЕ ИССЛЕДОВАНИЕ

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Резюме. Катетеризация для проведения продленной регионарной анестезии создает потенциальные условия для развития инфекционных осложнений. Частота их невелика, но в случае возникновения может привести к серьезным последствиям для пациента, а также увеличить длительность его пребывания в стационаре. Колонизация катетера микрофлорой в количестве 10^5 КОЕ и более означает, что имеется риск развития инфекционного осложнения. ***Цель исследования***: определить стратегию регионарной анестезии на основе данных о колонизации катетера в зависимости от способа его фиксации и длительности использования, а также определить превалирующий вид высеваемой микрофлоры. ***Материалы и методы***. В проспективное, открытое, сравнительное, одноцентровое исследование было включено 87 пациентов от 2 до 18 лет. Всем пациентам проводилась продленная регионарная анестезия, и в зависимости от способа фиксации катетера они были разделены на 3 группы: в первой группе применялась адгезивная наклейка (ФН), во второй — адгезивная наклейка и антимикробное покрытие Дезитол В (ФН + Д), в третьей проводилась туннелизация катетера (ФТ). Бактериологическое исследование микробной обсемененности проводилось классическим способом. ***Результаты.*** Ни у одного из 87 пациентов не было зарегистрировано признаков локального или системного инфекционного процесса. Разница в частоте колонизации между группами ФН и ФТ была статистически достоверна: χ^2 (1,N = 65) = 6,45 странные показатели (p = 0,011), между группами ФН и ФН + Д — недостоверна. Относительный риск колонизации кожной части катетера при фиксации наклейкой в 2,25 раза выше, чем при туннелизации катетера: RR = 2,25 (p = 0,05) (95% ДИ 1,069–4,73). В группе ФН + Д колонизация как кожной, так и внутренней части катетера отмечалась на достоверно более ранних сроках, чем в группе ФТ: кожная часть — U = 6,5; Uкр = 10; p = 0,018; внутренняя часть — U = 6; Uкр = 6; p = 0,047. При положительных результатах бактериального анализа наиболее часто была выявлена культура *St. epidermidis* (48,3%) и *St. aureus* (19,3%). ***Вывод.*** При планировании послеоперационного обезболивания длительностью 3 суток и более туннелизация является предпочтительным методом фиксации катетера.

Ключевые слова: регионарная анестезия; катетеризация; инфекционные осложнения.

INTRODUCTION

The technique of prolonged regional anaesthesia provides effective pain relief in postoperative period, reduces need for narcotic analgesics, and also promotes earlier recovery of patients after surgical treatment. However, a catheter through which local anaesthetic is administered, like any other catheter, is rightly identified as a possible entry point for infection. Infectious complications during regional anaesthesia are rare. However, if such conditions occur, undesirable consequences may develop, even catastrophic, as with the use of prolonged epidural analgesia [6, 9, 12, 18]. From the point of view of development of infectious complications, the most vulnerable patients are those with diabetes mellitus, cancer, multiple injuries, excess body weight, etc. [4, 5, 9]. In patients with neurological pathology, risk of catheter infection increases if they are immobile. These are either bedridden patients or walking patients, but immobilised during the recovery period after surgical treatment using plaster casts. Many patients also require long-term postoperative pain relief due to the high trauma of reconstructive surgery and accompanying general spasticity.

AIM

To determine the optimal strategy for reducing the risk of infectious complications during prolonged regional anaesthesia techniques. To achieve this goal, we compared colonisation of epidural or peripheral catheters depending on methods of its fixation and duration of its use. When confirming the colonisation of a catheter with microflora, we also determined the predominant type of microorganisms cultured.

MATERIALS AND METHODS

From January 2020 to December 2022, we conducted a prospective, open, comparative, single-center study at the Scientific and Practical Center for Children's Psychoneurology of the Moscow Department of Health. The study included 87 patients aged 2 to 18 years with an ASA score of II-III with congenital neurological pathology. The research was an initiative and was financed from the institution's budget funds allocated for treatment of hospitalised patients. The

patients underwent orthopedic surgical correction (operations on bones and tendons of upper and lower limbs in order to correct deformities). The volume, area and duration of surgical intervention dictated the need for antimicrobial prophylaxis in accordance with the Antimicrobial Stewardship (AMS) program [1] and clinical guidelines of the National Association of Infection Control Professionals (NAICP) [2]. Based on the program and strategy, the Scientific and Practical Center for Children's Psychoneurology has created an internal protocol for antimicrobial prophylaxis during orthopedic surgical operations. Antimicrobial prophylaxis was administered intravenously once 30–60 minutes before the start of surgery. Cefazolin was chosen as an antimicrobial drug, dose of the drug was 25 mg/kg, for a patient weighing more than 80 kg the dose was 2 g. Re-administration of the specified dose of antibiotic was carried out when the duration of surgical intervention was more than 4 hours.

Traumatic nature of surgical treatment determined the indications for use of one or another method of prolonged regional anaesthesia. When performing surgical interventions in the area of pelvic ring and hips, epidural anaesthesia was used, and when performing reconstructive operations in the area of foot, peripheral anaesthesia was used. Combined anaesthesia with mechanical ventilation was chosen as tactic of intraoperative pain relief.

After induction of anaesthesia and ensuring airway patency, either puncture and catheterisation of epidural space or locoregional anaesthesia with placement of a catheter to the nerve trunk or plexus were performed.

When performing regional nerve blockade, the following principles of asepsis and antisepsis were observed. Before performing the blockade, anaesthesiologist disinfected his hands, which consisted of washing the hands twice with a soap solution of 0.8 % alkyl dimethyl benzyl ammonium chloride (Dezaflor, Medlex, Russia) for 1 minute, drying with a sterile napkin. Then hand washing with a solution of Softasept N (ethyl alcohol 74.1 g, isopropyl alcohol 10 g per 100 g of finished solution, BBraun, Germany) twice for 1.5 minutes was performed. Mandatory conditions were short-cut nails, as well as the absence of artificial nails, rings and watches. During the blockade, the anaesthesiologist was equipped with a sterile coat, surgical mask, medical cap and sterile gloves.

A nurse-anaesthetist treated the patient's skin twice with Softasept N solution at intended site of catheterisation. After patient's skin dried, the anaesthetist limited the puncture site with a disposable sterile surgical drape with a hole and adhesive layer around it. The nurse-anaesthetist unpacked sterile disposable kit for epidural or peripheral prolonged anaesthesia, syringe for local anaesthetic, and sterile wipes. Then she laid them out on prepared sterile table in compliance with aseptic rules.

After epidural or peripheral regional anaesthesia, we fixed the catheter, and according to the method of fixation, the patients were divided into three groups:

- the first group: patients in whom catheter fixator made of adhesive materials was used — an adhesive sticker (AS — fixation with a sticker, N = 26);
- the second group: patients in whom, before using the adhesive catheter fixator, the puncture area was treated with a three-component antimicrobial coating (AS + D — fixation with a sticker + Desitol, N = 22);
- the third group: patients who underwent catheter tunneling (T — fixation with a tunnel, N = 39).

In the first group of patients, we used the Perifix catheter fixator (BBraun, Germany), which consists of two parts: an adhesive fixing polyurethane ring and transparent film sticker with a non-adhesive central part. The epidural catheter was placed in a loop under the adhesive fixing ring so that the point where the catheter exited the skin was located in the center of the ring, and a catheter loop was under the adhesive ring. A transparent film sticker was fixed on top.

In the second group, before using the catheter retainer, an antimicrobial prophylactic coating with dye (Dezitol B, Dezitall, Russia; composition: 70 % isopropyl alcohol, a complex of quaternary ammonium compounds (QAC), D-panthenol) was used from a sterile dispenser. Desitol B is a viscous liquid. We used a disposable polymer sterile spatula to apply it. The application area was approximately 9 cm^2 and covered the area where the catheter exited the skin and part of the catheter placed in the loop for subsequent fixation. Subsequently, the catheter loop was fixed after the antimicrobial coating had completely dried. It was confirmed by the absence of stickiness of coating (the drying time of Desitol B was on average 2–3 minutes).

In the third group of patients, the catheter was tunneled (Fig. 1, 2). To form a subcutaneous tunnel, we used a peripheral venous catheter with a needle (PVC). It was inserted subcutaneously, retreating 3 cm cranial to the exit site of the epidural/perineural catheter with the needle tip directed 3–4 mm lateral to the exit of the catheter from the skin. After removing the needle, we retrogradely passed an epidural/perineural catheter through the lumen of the PVC until it exited the pavilion, then the PVC was removed. When a small loop remained above the skin, a tubular bridge was placed in it to prevent the catheter from breaking, and the loop was tightened. The tunnelling site was covered with a sterile fixing sticker. After puncture and catheterisation of the epidural or perineural space, a local anaesthetic (ropivacaine 0.2 %) was administered as a bolus, the dose and volume of which were calculated individually.

Fig. 1. Catheter tunneling
Рис. 1. Туннелизация катетера

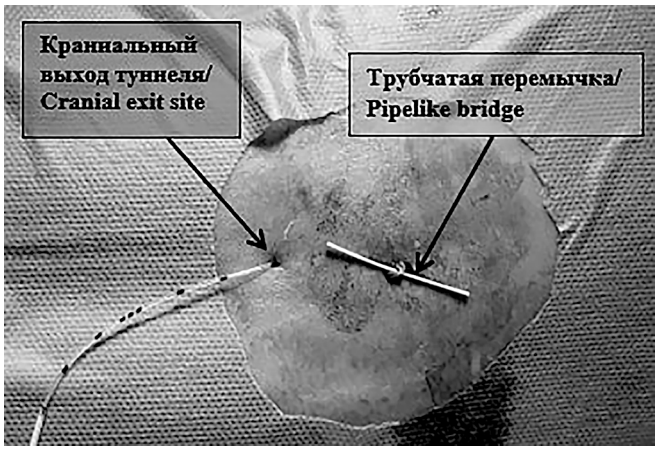

Fig. 2. View of the tunneled catheter after tightening the loop
Рис. 2. Вид туннелизированного катетера после затягивания петли

After surgery, all patients had their limbs fixed with plaster casts, so they were immobile in the immediate postoperative period. During observation in intensive care unit, children were in supine position, but the position was periodically changed to carry out exercise therapy in accordance with adopted strategy for early physical rehabilitation of patients in intensive care unit. Infusion therapy with anaesthetic (ropivacaine 0.2%) was performed only in intensive care unit. The effectiveness of analgesia was monitored every 2 hours using pain scales, and catheters were examined daily by an anaesthesiologist. The follow-up examination included visual assessment of the puncture area for local signs of inflammation and accumulation of blood or effusion under the patch. Routine change of the sticker was performed 3 days after the puncture or earlier if such a need arose (presence of blood or effusion under the sticker). To change the sticker, the doctor put on a medical cap and surgical mask, changed the sticker in sterile gloves, treated the puncture area with a solution of Softasept N.

Before transferring patients to surgical department, the catheter was removed. Removal of catheters for the purpose of further microbiological examination was carried out in a ward under aseptic conditions, excluding the possibility of secondary contamination of catheters with microorganisms. Before removing a catheter, a doctor put on a medical cap and surgical mask, disinfected his hands surgically, put on a sterile coat and sterile gloves. The catheter area was separated with a disposable sterile surgical drape with an adhesive edge. The fixing sticker was removed using sterile gloves, after which the gloves were changed to new pair. When selecting the outer and inner parts of the catheter for bacteriological culture, no preliminary antiseptic treatment of skin was performed.

Sterile tweezers and sterile scissors were used when removing the catheter and dividing it into fragments for microbiological examination. To determine the area of possible contamination, each catheter was divided into two parts — the outer and the inner. In the first two groups, a part of the catheter located under the adhesive sticker was considered the outer part. In the group where the catheter tunnelling was used, a part located in the region of subcutaneous tunnel was considered outer part. The internal part, regardless of the method of fixing a catheter, was the part between skin and epidural or perineural space. For bacteriological examination, the inner and outer parts of the catheter were divided, respectively, into 6 fragments, which were placed in sterile test tubes. Containers with material (12 test tubes with catheter fragments) for bacteriological examination were transported to laboratory in a separate box.

Bacteriological examination of microbial insemination was carried out by direct sowing of fragments of catheters in growth media.

The material was sown in a fluid thioglycollate medium and sabouraud liquid medium (with an inhibitor of foreign microflora — potassium tellurite). For each medium, 2 parallel experimental samples were placed (for this reason, 6 fragments of each part of the catheter were required). Mandatory control was carried out on both specified nutrient media. The bacteriological cultures were kept in a thermostat for 7 days in a thioglycollate medium at temperature of 32 °C. The sabouraud liquid medium was 22 °C. In the absence of growth of microorganisms in all test tubes during the specified period, sowing was carried out on solid nutrient media (5% blood agar, HiMedia *Staphylococcus* chromogenic agar, *Candida* chromogenic agar) for control purposes. In the absence of growth on a Petri dish, a conclusion was issued that the catheter was not inseminated.

If there was growth, a microscopic (bacteriological) examination of a Gram staining was performed. Depending on the grown microflora, material was sown on the correspon-

ding solid media (5 % blood agar, HiMedia *Staphylococcus* chromogenic agar, *Candida* chromogenic agar, in the presence of gram-negative rods — HiCrome Urinary Tract Infection Agar) using the "swab-loop" method. It made it possible to evaluate the growth of microflora not only quantitatively, but also qualitatively. Colony forming units (CFU) were measured after 24 hours, and the degree of contamination was determined in CFU/ml.

During primary growth on solid nutrient media, re-plaiting was performed on differential media to clarify the qualitative composition of the microflora. Erba Lachema kits (Czech Republic) were used to identify microorganisms. Identification of microorganisms of genus *Staphylococcus* was carried out using the STAFI-test 24. To make biochemical identification of clinically significant microorganisms of the order *Enterobacterales*, ENTERO-test 24 was used, and to identify microorganisms of the genus Enterococcus to the species level Encoccus-test was performed. To identify gram-negative non-fermenting bacteria NEFERM-test was used. The genus of the microorganism was determined using the computer program Microb-2 (Russia).

In conclusion, a laboratory provided information on the qualitative and quantitative composition of the microflora or the absence of growth.

STATISTICAL ANALYSIS

Sets of discrete indicators are presented as median (Me) and quartile (Q1–Q3) values. Mann–Whitney U test was used to determine differences between sets of discrete variables. The infection rate was expressed as percentage of the total number of catheters. When comparing the frequency of positive bacterial cultures in different groups, the Pearson's chi-squared test was used. In case of detection of statistically significant differences, the relative risk of infection was determined for different fixation methods. The correlation between the duration of catheter use and frequency of positive bacterial culture results was described using the rank-biserial correlation. Strength of the relationship was assessed using the Chaddock scale.

RESULTS AND DISCUSSION

Throughout the study, we recorded the presence or absence of local skin changes in the catheter area, signs of infectious process, duration of catheter use, and (after receiving data from the laboratory) presence or absence of colonisation of the catheter with microflora. The area of catheter colonisation (internal or external part of the catheter) and type of microflora cultured and the number of CFU were determined.

The incidence of local changes in skin, which consisted of hyperaemia around the catheter (radius 1–2 mm), was 9.2 % (8 patients), and seven of them were in group who underwent catheter tunneling (T) and one of them had fixation using an adhesive sticker (AS). In the group where the antimicrobial coating (AS + D) was used, the local skin changes were not observed in any patient. We may assume that the absence of local skin hyperaemia was due to the presence of D-panthenol in composition of Desitol, or that skin hyperaemia of a small diameter was difficult to visualise due to the green dye, which is also part of Desitol.

The obtained data are similar to the results published in international studies. The incidence of local signs of inflammation at the site of catheter exit from skin, according to different authors, varies from 0 to 16 % [8, 10, 14, 15]. In these studies, a catheter was fixed with a sticker. In our research, in most children (7 out of 8) in whom we noted skin hyperaemia at the catheter exit site, it was fixed with a tunnel. Local changes were only at the site of catheter exit from the cranial part of the tunnel. Only one of these seven patients had a positive result of bacterial inoculation (on both parts of the catheter — external and internal). In the T group, the patient, who had hyperaemia at the site of catheter exited body, also had an increase in microflora on the outer part of the catheter. In this regard, we suggested that skin hyperaemia around the catheter may be a manifestation of local inflammatory reaction. Also, it may occur due to mechanical impact of the catheter on surrounding tissues. The catheter at the point of exit from skin exerts pressure on it, as if pushing the edges apart.

In our study, the presence of local skin lesions does not mean that the result of the bacterial inoculation will be positive or vice versa. Similar conclusions are made by N. Seth et al. [14]. In their study, only 43 % of patients had positive results of bacterial inoculation among children who had local changes in the area where the catheter exited skin. At the same time, the authors recorded that in 30 % of cases bacterial inoculation was also positive in patients who did not have signs of inflammation on the skin. A.M. Morin et al. [10] in their study also provides data showing that only 18 of 33 patients who had colonisation were found to have local changes in the area where a catheter exited the skin.

Colonisation of the catheter with microflora in the amount of 105 CFU or more means that there is a risk of developing an infectious complication. The number of CFU is increasing in parallel with the risk. Although the incidence of infectious complications is generally low, vigilance is required for the first symptoms to detect them [18]. In 2007, a meta-analysis of 12 studies, which included 4628 patients,

was published [13]. According to presented data, the frequency of infectious complications was 6.1 %, 4.6 % had superficial inflammation, and 1.2 % had infectious lesions deeper than the dermis. In 10 of the 12 studies included in the meta-analysis, infectious complications were recorded in less than 2 % of patients. In 9 studies, an infectious process developed in 2.8 % patients with cancer with duration of catheterisation of 74 days.

In our study, none showed signs of local or systemic infection, also there were no symptoms such as fever, pain at the puncture site, back pain or radiculopathy.

The percentage of colonisation frequency differed between the groups. The highest frequency of positive results of bacteriological examination was recorded in the first group (AS) and amounted to 53.8 %. In the group where Desitol (AS + D) was used, colonisation rate was 31.8 %, and in the group where tunnelisation (T) was performed, it was 23 %. The difference in the colonisation rate between the AS and T groups was statistically significant: χ^2 (1,N = 65) = 6.45 (p = 0.011). It seems that the use of Desitol also allows significantly reduce the risk of catheter colonisation, however, modern methods of statistical analysis have shown that this statement is unreliable: χ^2 (1, N = 48) = 2.34 (p = 0.12).

In various studies, the frequency of positive catheter culture test results varies from 5.8 to 57 % [7, 8, 10, 11, 14–18]. Such significant scatter in the data on positive culture test results is explained by the fact that in some studies only catheter tips were selected for bacteriological examination, and the skin was pre-treated [11, 15, 16]. At the same time, in other studies either growth was recorded on the cutaneous and subcutaneous part of the catheter, or a smear from the patient's skin in the area of the catheter exit was examined [7, 8, 10, 14, 17, 18]. Therefore, it resulted in higher percentage of positive samples. The obtained results are in line with the data from the cited studies.

Statistically significant difference in the incidence of skin catheter infection was found between the T and AS groups: χ^2 (1,N = 65) = 4.81, p = 0.028. The relative risk (RR) of skin catheter infection with sticker fixation was 2.25 times higher than the risk of infection with intradermal tunnelling fixation: RR = 2.25, p = 0.05 (95 % CI 1.069–4.73).

For other methods of fixation, differences in the frequency of infection of both epidural and cutaneous parts were statistically insignificant (Table 1).

Our results are consistent with the data of numerous studies. According to some authors, the positive results of microbiological examination of a smear from the skin in the area of the catheter or from the skin part of the catheter vary from 32 to 38 % [8, 14, 18], and the frequency of colonisation of the catheter tip varies from 5.8 to 35 % [8, 11, 14, 15, 18].

In 2016, data from a large-scale study conducted in Germany were published. The study included 22,411 patients who had epidural anaesthesia for 4 days or more [3]. The authors compared the incidence of infectious complications depending on the method of catheter fixation: 12,870 patients underwent tunnelling, and 9,541 patients had the catheter fixed with a sticker. Catheter tunneling has been shown to reduce the risk of infectious complications. In our study, we noted the lowest frequency of colonisation of the skin part of the catheter in the T group, which is consistent with the data of the cited study. In addition, tunnelling provides more reliable fixation of the catheter, which is important when performing prolonged anaesthesia in children.

We also noted that with tunnelling, catheter colonisation was observed at a later time than in the other study groups.

The duration of catheter use in the groups was in hours: (Me (Q1-Q3)) first group (AS) 72 (24-96), second group

Table 1

The frequency of colonization in the study groups

Таблица 1

Частота колонизации в исследуемых группах

Группа / Groups	Длительностькатетеризации, часы Me (Q1-Q3) / Duration of catheterization, hours (Me (Q1-Q3))	Колонизация, % / Colonization, %	Колонизация (кожная часть), % / Colonization (skin part), %	Колонизация (внутренняя часть), % / Colonization(inner part), %
ФН / AS	72 (24–96)	53,8*	46#	30
ФН + Д / (AS + D)	36 (24–48)	31,8	27,3	23
ФТ / (T)	96 (72–120)	23*	20,5#	23

* Разница между группами статистически достоверна: χ^2 (1,N = 65) = 6,45 (p = 0,011). / The difference between the groups is statistically significant: χ^2 (1,N = 65) = 6,45 (p = 0,011).

Разница между группами статистически достоверна: χ^2 (1,N = 65) = 4,81 (p = 0,028) / The difference between the groups is statistically significant: χ^2 (1,N = 65) = 4,81 (p = 0,028).

(AS + D) 36 (24-48), third group (T) 96 (72-120). There was positive correlation between the duration of catheterisation and frequency of catheter colonisation (Table 2).

In patient using Desitol, colonisation of both the skin and internal parts of the catheter was noted at significantly earlier stages than with tunneling: skin part of the catheter U = 6.5; Ucr = 10; p = 0.018; internal part of the catheter U = 6; Ucr = 6; p = 0.047.

The difference in the time of colonisation of the catheter by microflora in the tunneling and adhesive sticker groups, as well as in the adhesive sticker and Desitol groups, was statistically insignificant.

When fixing with a sticker, moderate statistically significant positive correlation was observed between the frequency of infection of the skin part of the catheter and duration of its use. The rank-biserial correlation coefficient between the duration of catheter use and frequency of positive cultures of the skin part: $r_{rb} = 0.46$, $p = 0.025$. The correlation between the frequency of infection of the internal part and duration of catheter use when fixing with a sticker was weak and statistically insignificant: $r_{rb} = 0.36$, $p = 0.07$.

When using Desitol, there was moderate correlation between the frequency of positive bacterial cultures and duration of catheter use (for the internal part of the catheter): $r_{rb} = 0.48$, $p = 0.02$. For the skin part of the catheter: $r_{rb} = 0.42$, $p = 0.048$, respectively.

In case of catheter tunnelling, no relationship was found between catheter colonisation with microflora and duration of catheter use. There were no statistically significant differences in the frequency of microflora growth on the inner part of the catheter between groups.

The figures demonstrate the dynamics of microflora growth on the skin (Fig. 3) and internal (Fig. 4) parts of the catheter depending on the duration of its use.

In 2018, Bomberg et al. [6] published results of a large study on infectious complications during prolonged regional anaesthesia. A retrospective data analysis provided by a German regional anaesthesia network comprising 25 centres was performed. The study included 44,555 patients who underwent continuous peripheral or neuraxial anaesthesia for pain relief after surgery. According to the authors, safety in terms of the risk of catheter infection during peripheral

Table 2

Timing of catheter colonization in study groups (Me (Q1-Q3))

Таблица 2

Сроки колонизации катетера в исследуемых группах (Me (Q1-Q3))

Часть катетера / Part of a catheter	ФН / AS	ФН + Д / AS + D	ФТ / Т
Наружная часть (кожная) / Outer part (skin)	84 (66-120)	48 (48-72)	96 (96-120)
Внутренняя часть / Inner part	96 (60-120)	60 (48-72)	96 (96-120)

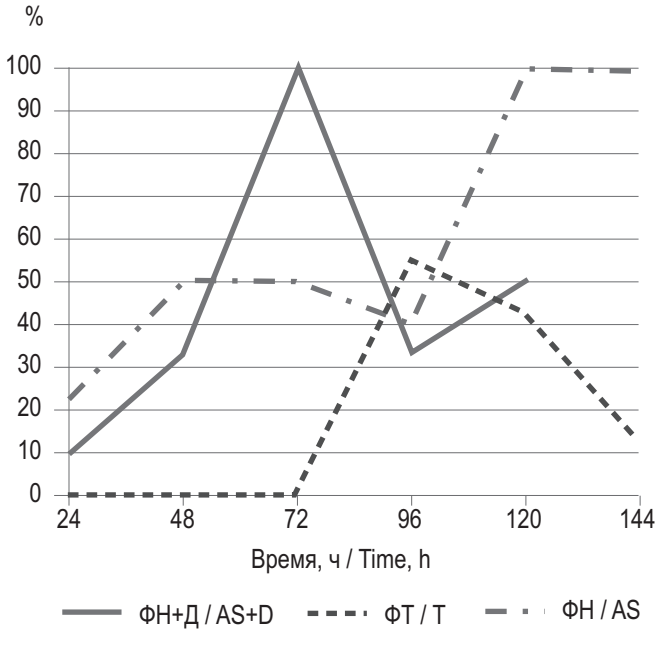

Fig. 3. Growth rates of microflora,on the outer part (skin) of the catheter /

Рис. 3. Динамика роста микрофлоры на наружной (кожа) части катетера

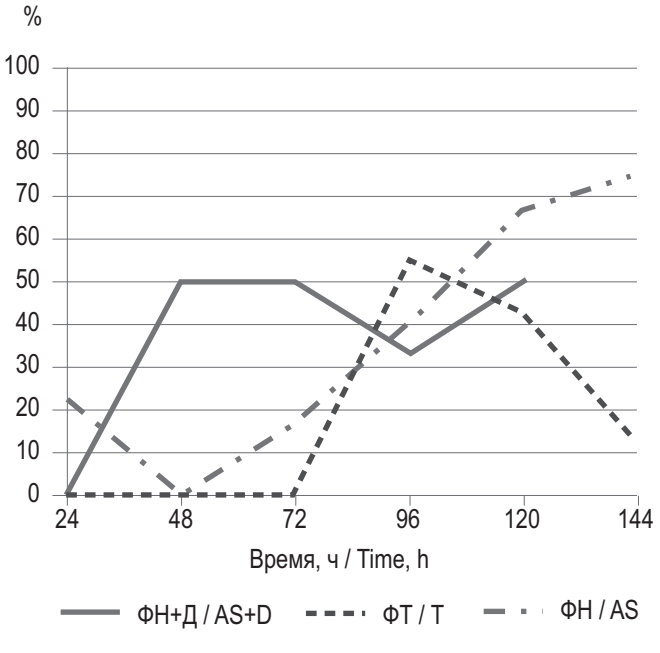

Fig. 4. Growth rates of microflora on the inner part of the catheter /

Рис. 4. Динамика роста микрофлоры на внутренней части катетера

blockade on the fourth day is 99 %, on the seventh — 96%, on the fifteenth day — 73 %; during epidural anaesthesia on the first and fifteenth day, these indicators were the same as during peripheral anaesthesia (99 and 73 %, respectively), on the seventh day — 95 %. According to the results, probability of developing infectious complications increases with each day, especially after the fourth day of catheter use. In our study, we did not note some connection between the colonisation of the catheter with microflora and duration of its use in the group where the catheter was tunneled. Also the duration of catheterisation in this group was 96 (Me (Q1-Q3)) (72-120) hours. Thus, the results of the study are consistent with the results of the authors.

According to various data, when conducting microbiological examination, the most common growth detected both at the catheter tip and on the skin is *Staphylococcus epidermidis* or *Staphylococcus aureus* [7, 8, 10, 11, 13, 15–18]. In our study, we obtained similar data. The most frequently detected cultures were *Staphylococcus epidermidis* (48.3 %) and *Staphylococcus aureus* (19.3 %). It is important to note that only in the AS group there was an increase in pathogenic microorganisms (*Photorhabdus asymbiotica)* in two patients (6.5 %). The number of CFU in most cases did not exceed 105. Only in two patients of the AS group, the number of CFU *S. epidermidis* was 107 and 108. However, no signs of an infectious process were observed in any of the patients. The exact results of the microbiological examination are shown in Figure 5.

In case of microflora growth on both parts of the catheter, there were no differences in type of detected microorganisms. Therefore, we can conclude that the penetration of microflora to the epidural part of the catheter with subsequent colonisation occurs through the catheter itself from the skin surface. When selecting the inner part of the catheter for microbiological examination, preliminary antiseptic treatment of the skin was not performed, therefore, the possibility of infection of the epidural part of the catheter during sampling cannot be excluded.

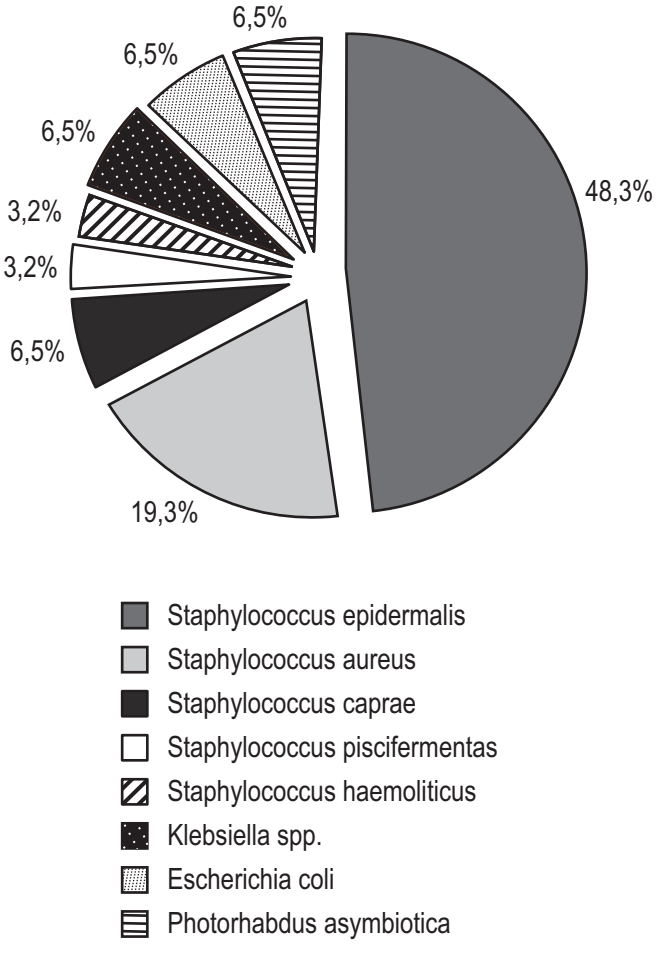

Fig. 5. Results of bacteriological examination of microflora
Рис. 5. Результаты бактериологического исследования микрофлоры

CONCLUSION

Tunneling is preferred method of catheter fixation if the planned period of postoperative analgesia is 3 days or more. Tunneling was associated with the lowest frequency of colonisation of the skin part of the catheter. Colonisation of both the skin and internal part of the catheter occurred at later stages than when the adhesive sticker or its combination with Desitol was used. In case of T, no relationship was found between the duration of catheter use and frequency of catheter colonisation.

Relationship between the duration of catheter use and frequency of infectious complications was noted only in the AS and AS + D groups. It was also found that in these groups, approximately the same duration of protection from colonisation of the internal part of the catheter is ensured for catheterisation periods of up to 2 days. This method of fixation practically does not protect against colonisation of the skin part of the catheter, but does not lead to development of any infectious complications during the first 2 days. The frequency of colonisation of the internal part of the catheter did not differ significantly between all three groups.

Limitations of the study: No method of antiseptic skin treatment provides 100 % destruction of skin microflora, which may remain in the ducts of sweat and sebaceous glands.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be

published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

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Consent for publication. Written consent was obtained from the patient for publication of relevant medical information within the manuscript.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Источник финансирования. Финансирование осуществлялось за счет бюджетных средств учреждения, направленных на лечение госпитализированных больных.

Информированное согласие на публикацию. Авторы получили письменное согласие пациентов на публикацию медицинских данных.

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