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Effect of Different Methods of Anesthesia on Surgically Created Arteriovenous Fistula

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Summary

Aim of the study was to determine the advantages of peripheral nerve blocks (PNB) versus local infiltration anesthesia (LIA) in the formation of arteriovenous fistula (AVF) surgically created for hemodialysis treatment

Type of study: prospective non-randomized study. Approved by the ethics committee of JLF UK in Martin.

Type of workplace: clinical workplace of a university hospital.

Material and method. The cohort of patients (*N*=40) who required arteriovenous fistula (AVF) creation was divided into 2 groups, 20 patients each: patients operated under peripheral nerve blockade and patients operated under local infiltration anesthesia. The preserved function of the fistula was monitored 24 hours, 6 weeks and one year after the operation, without revision. Patient inclusion criteria included: age 19–75 years, ASA 3–4, weight 40–120 kg, BMI up to 40. Statistical treatment of data included Mann-Whitney exact test, Fisher's test, *t*-test, Shapiro–Wilk normality test.

Results. After 24 hours, all fistulas created with peripheral nerve blockade were functional whereas only 90% developed under local infiltration anesthesia remained functional ($P>0.05$ between groups). However, after 6 weeks, 80% of fistulas created under peripheral nerve block were functional, compared to 50% of functional fistulas created in patients under local infiltration anesthesia ($P=0.048$). One year after surgery, the difference remained as a trend since 55% of fistulas created under peripheral nerve block remained functional while only 35% of fistulas created in patients receiving local infiltration anesthesia were functional without complications ($P=0.097$).

Conclusion. In our study, the peripheral nerve block anestesia seem superior in term of improved survival of created fistula compared to local infiltration anesthesia.

Keywords: brachial plexus block; local infiltration anesthesia; peripheral nerve block; arteriovenous fistula

Conflict of interest. The authors declare no conflict of interest.

Introduction

Supraclavicular block of the brachial plexus is a relatively new form of anesthesia used in the surgical creation of arteriovenous fistulas (AVF) on the distal forearm [1]. These are currently the gold standard of vascular access for patients who require chronic hemodialysis treatment. In Europe, local infiltration anesthesia (LIA) is still the most common type of anesthesia for AVF formation. There are several reasons. It is simple to perform, safe, does not require the presence of an anesthesiology team, is not time-consuming and is cheap. However, early or late AVF failure is common, most often due to stenosis, poor maturation or thrombosis of the fistula. In the USA, general anesthesia (GA) is often used, but it does not have the advantages of local infiltration anesthesia and poses an increased risk in this group of patients with numerous comorbidities [2, 3]. Therefore, in recent years, peripheral nerve blocks (PNBs) that represent supraclavicular brachial plexus block with ultrasound navigation have also been promoted, which seem to have certain advantages over GA or LIA [4]. Several studies have recently been conducted that support this view. They compared LIA and PNB or LIA and GA [5, 6]. Comparison of all three types of anesthesia is rare [7]. A large multicenter randomized trial ACCess comparing PNB and LIA is currently underway in the UK. The results should be published in 2025 [8]. In our study, the LIA and PNB were compared. The study took place between January 2020 and May 2022.

The aim of the study was to determine the advantages of peripheral nerve blocks (PNB) versus local infiltration anesthesia (LIA) in the formation of arteriovenous fistula (AVF) surgically created for hemodialysis treatment.

Material and Methods

The set of patients was in ASA category 3 or 4, comorbidities were similar with respect to chronic kidney damage, comorbidities were more significant in older patients. After informed consent, the patients chose the method of anesthesia (PNB or LIA) by themselves. A total of 40 patients were included in the study. Twenty patients were operated under PNB and 20 patients received LIA.

PNB was performed as a supraclavicular block of the brachial plexus under dual navigation by ultrasound and neurostimulation. 20 mL of 0.5% levobupivacaine and 10 mL of 1% trimecaine were administered. We have chosen this PNB method because of relatively simple execution and high efficiency even with a less experienced anesthesiologist to decrease the risk of failure. A higher dose of local anesthetic was supposed to ensure a longer duration of PNB and an expected increased and long lasting effect on the sympathetic system and dilation of the vessels of the operated limb [8]. Neurostimulation was used mainly for educational reasons [9]. LIA was administered by the surgeon in a total dose of 20 mL of 1% trimecaine. Inclusion criteria for the study were age 19–75 years, ASA 3–4, weight 40–120 kg, BMI up to 40. Standard anesthesia monitoring was used for LIA and PNB and included ECG, NIBP, SpO_2 monitoring. The primary AVF was created in the area of the distal forearm above the wrist of the non-dominant hand, the skin incision was also more or less identical, the operators were three experienced vascular surgeons.

The primary monitored indicators were: AVF functionality 24 hours after the operation (pulsation of the draining vein and auscultation murmur above the fistula) and after 6 weeks after the operation (the flow and parameters of the supply and draining vessels were monitored sonographically), when the AVF was considered mature. We also monitored the functionality of the fistula one year after the operation without the need for intervention.

Another important monitored parameter was the change in diameter of a. radialis after the administration of anesthesia compared to the initial value and the change in diameter of v. cephalica after administration of anesthesia compared to the initial value. Measurement of blood vessels in the location of planned AVF creation was performed sonographically at an accuracy of 0.1 mm.

We also monitored the following parameters: 1) the time required to perform the operation and the length of anesthetic care for individual groups, 2) the occurrence of serious adverse events requiring medical intervention during the operation for individual types of anesthesia (cardiovascular, respiratory, neurological), 3) the visual analog scale (VAS) of pain value at the end of anesthesia and the highest value of VAS during the first 24 hours after the operation, and 4) the necessity of administration of analgesics during the first 24 hours after the surgery. Statistical methods used in study: Mann–Whitney exact test, Fisher's test, *t*-test, Shapiro–Wilk normality test. Even in a small cohort with a sample size of N=20, after testing for the normal distribution, the Student's *t*-test exhibited sufficient validity and reliability.

Results

No final conclusions can be drawn due to the small cohort of 40 patients in the study. There were 15 men and 5 women in the LIA group, aged from 36 to 75 years, the average age was 64.2 years. There were 16 men and 4 women in the PNB group, in a range of 28–75 years old, the average age was 57.7 years.

When comparing the effect of methods of anesthesia on the diameter a. radialis in the distal forearm of the operated limb, we found that in PNB, there was an average dilation of 0.45 mm (average +20.4%), In patients under LIA, dilation occurred by an average of 0.09 mm (an average of +4.8%). Compared to LIA, there was a statistically significant dilation of artery diameter in patients under PNB (P=0.0003, *t*-test). When comparing the change of diameter of v. basilicae in the distal forearm of the operated hand after administration of individual types of anesthesia, we found that in patients under PNB there was an average dilation of 0.93 mm (average 51.6%), whereas patients under LIA exhibited the average change in the lumen of the vein by 0.13 mm in terms of vasoconstriction (average –1%). When comparing PNB versus LIA, there was a statistically significant change in a vessel diameter in terms of dilation in PNB group compared to LIA group (P=0.000025, *t*-test).

When monitoring AVF functionality 24 hours after surgery, we found that there was no early failure of function in fistulas created in PNB and early failure in 10% of fistulas in LIA. No significant differences in AVF functionality after 24 hours were revealed between the PNB and LIA groups (P=0.487, Fisher test).

When monitoring the functionality of the AVF after 6 weeks from the operation in individual groups of anesthesia, we found that 80% of the fistulas created in the PNB were functional. For fistulas created in LIA, only 50% of fistulas were functional after 6 weeks. When comparing PNB versus LIA, a significant difference in fistula survival was found in favor of PNB (P=0.048, Fisher test).

When monitoring the functionality of the fistula without complications one year after the operation, 55% of fistulas created under PNB and 35% created under LIA were functional without complication or any intervention. There was, however, a marginal trend toward difference in fistula survival in favor of PNB (P=0.097, Fisher test).

We also compared the length of anesthesia care in the operating room for individual types of anesthesia. PNB anesthetic care was significantly longer than LIA care (P=0.017, *t*-test). Another monitored parameter was the duration of surgery for individual types of anesthesia. The duration of the operation under PNB compared to LIA differed significantly, with PNB the performance was shorter (P=0.012, *t*-test).

The incidence of adverse events and effects on methods of anesthesia was as follows: in PNB patients it was 5% and in LIA patients there were no such events. The occurrence of adverse effects during surgery between RA and LA was statistically

Table. Values of monitored parameters, valid cases *N*=20.

Parameters	95% CI	Mean	Median	Standard deviation	Quartil		Interquartile range
					Lower	Upper	
Change of diameter of a. radialis in PNB, mm	0.3–0.6	0.46	0.45	0.2542	0.3	0.6	0.3
Change of diameter of a. radialis in LIA, mm	0–0.3	0.13	0.15	0.2975	0	0.3	0.3
Change of diameter of v. cephalica in PNB, mm	0.5–1.5	1.03	1	0.882	0.5	1.65	1.15
Change of diameter v. cephalica in LIA, mm	–0.7–0.4	–0.115	0.1	0.691	–0.75	0.4	1.15
PNB — length of anesthesia care, min	130–165	148	142.5	28.81	127.5	170	42.5
LIA — length of anesthesia care, min	100–155	125.75	117.5	37.14	95	157.5	62.5
Duration of surgery in PNB patients, min	60–80	77.75	75	25.26	60	85	25
Duration of surgery in LIA patients, min	65–120	94.25	90	35.88	65	120	55
Maximal VAS 24 h after surgery in PNB patients	0–4	1.7	0.5	2.13	0	4	4
Maximal VAS 24 h after surgery in LIA patients	0–3	1.35	0.5	1.4965	0	3	3

insignificant (*P*=1, Fisher test). There were no critical incidents during the study.

We investigated further, whether there was a difference in VAS when the patients left the operating room. There was no significant difference between PNB patients and LIA patients (*P*=1, Fisher's test).

When monitoring the maximum VAS during the first 24 hours after surgery, no significant difference between PNB patients and LIA patients found (*P*=0.7, Mann–Whitney exact test). The average maximum of VAS value was 1.7 in PNB group and 1.35 in LIA group.

The last monitored parameter was the need to administer analgesics during the first 24 hours after the procedure. The need for administration of analgesics had been revealed in 40% of patients receiving PNB and in 65% of patients receiving LIA. The association between the groups during the first 24 hours after the procedure, however, was insignificant (*P*=0.63, Fisher's test). Descriptive statistical results are presented in a table.

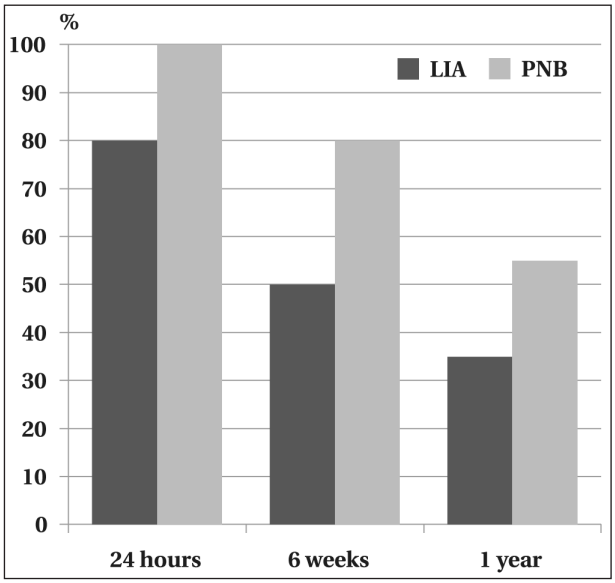

Fig. 1. Functionality of fistulas after operation.

Discussion

Our study was focused on comparing several parameters when using different types of anesthesia. The main monitored parameter was the preserved functionality of the fistula 24 hours after the operation, 6 weeks after the operation, when the fistula is already considered mature, and after 1 year. Twenty-four hours after surgery, all AVFs created under PNB were functional, and 10% of AVFs failed in LIA. Significant difference between PNB and LIA in term of AVF functionality was absent at this time point. Primary failure of AVF had been further compared depending on a method of anesthesia. Six weeks post-surgery, when AVF maturation should have occurred, 80% of AVFs formed under PNB anesthesia were functional. At the same time point, only 50% of the AVFs created in the LIA remained functional with significant differtence in fistula survival in favor of PNB. One year after the operation, 55% of fistulas created by PNB and only 35% of fistula created under LIA were functional without complications (Fig. 1). the results suggest that it might be more advantageous to use PNB because of better AVF functionality.

Another important monitored parameter was the effect of individual types of anesthesia on a lumen of *a. radialis* and *v. cephalica* in the distal forearm, i.e. at the site of creation of the primary fistula. Local anesthetic administered by infiltration at the site of surgery generally has a vasodilating effect depending on its concentration. Higher concentrations of anesthetic provided incerased vasodilating effect, whereas lower concentrations remained neutral or even slightly vasoconstrictive [10]. Under PNB, the local anesthetic by blocking sympathetic nerve fibers causes significant vasodilatation in the innervated area [11].

We found that arterial dilatation occurred in all types of anesthesia, with average dilatation of 20.4% in PNB group and only 4.8% in LIA patients. When comparing PNB versus LIA, there was a statistically significant dilatation in PNB patients. When comparing the change in lumen diameter of *v. basilicae* after administration of individual types of anesthesia, we found that in

patients recceiving PNB the dilation occurred by an average of 51.6%, whereas in LIA patients the lumen of the vessel even decreased by an average of 1% (Fig. 2). When comparing the vasodilation effect in PNB and LIA groups, there was a statistically significant change in a vessel diameter in terms of dilation in PNB patients compared to LIA patients. These changes in the lumen of the vessels in the area of the distal forearm, i. e. in the place where the AVF was subsequently created, seem to have had a significant impact on the duration of the surgical procedure and the functionality of the AVF itself after 24 hours, 6 weeks and 1 year. Vasodilation of both vessels used in AVF creation had an impact on operative technique, when the operator could work more easily on wider vessels, and a few hours after the operation, the persistent vasodilation improved primary functionality of the AVF.

The length of anesthesia care in the operating room was statistically significantly longer with PNB than with LIA, it is related to the time needed to perform the block and its onset. It can be reduced by performing a blockade outside the OR by another team.

When monitoring the time needed to perform the operation, we found that when comparing PNB and LIA, the operation time was statistically significantly shorter with PNB. From this it can be concluded that PNB, if performed outside the operating room, can speed up the operation in the operating room.

When monitoring adverse events and effects in individual types of anesthesia (we monitored the occurrence of severe hypertension, hypotension, arrhythmia, cardiovascular and neurological complications with the need for therapeutic intervention), the incidence was only 5% in PNB group (1 patient with symptomatic arterial hypertension). No such events occurred under LIA. The incidence of adverse events during the procedure was not significant when PNB and LIA were compared. There were no critical incidents. If we consider the administration of PNB, it is necessary to take into account anticoagulant or antiplatelet treatment, which may represent a relative contraindication for the administration of PNB [12].

There was no statistically significant difference between PNB and LIA when monitoring the VAS when leaving the operating room or the maximum VAS during the first 24 hours after the operation.

The last monitored parameter was the need to administer analgesics in individual anesthesia groups during the first 24 hours after the procedure. Administration of analgesics required in 40% of PNB patients and in 65% of LIA patients. The association between the PNB and LIA groups was only statistically insignificant (P>0.05 between groups).

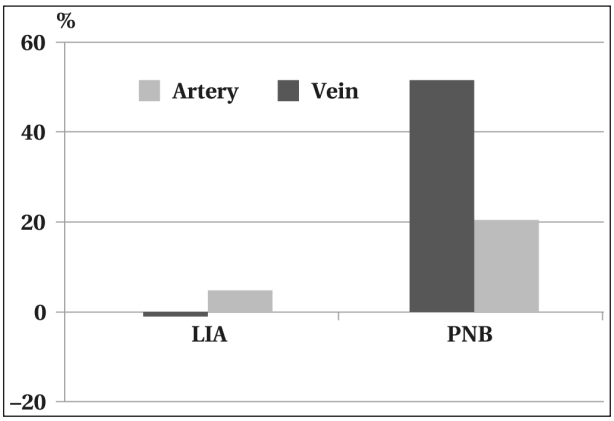

Fig. 2. Change in vein and artery diameter after administration of different types of anesthesia.

Our data confirm previously published results of other studies [13–16].

Patients with chronic renal failure who are being prepared for hemodialysis treatment or have an acute dialysis catheter in place and are indicated for the AVF creation in the forearm for hemodialysis represent a serious medical problem for a relatively broad group of patients. This group may include patients from young adults to elderly patients who are varying in diagnosis that causekidney failure. They usually have developed a wide spectrum of diseases associated with renal failure and fall into the ASA classification of anesthetic risk 3 or more (commonly, risk 4). General anesthesia itself can represent a relatively high risk for them [17, 18]. The operation is performed on the vessels of the forearm (*a. radialis* and *v. cephalica*), and the non-dominant hand is preferred. Vascular conditions are often limited by a narrow lumen or sclerotic changes in the vessels. This complicates the operative technique during the operation itself and often causes early or late failure of the AVF function and necessitates reoperations, radiointervention procedures, or formation of a new fistula proximally, or using the other upper extremity. Sometimes it is necessary to insert an acute or permanent hemodialysis catheter until a new fistula is formed. This entails the risk of various serious medical complications, exposes the patient to repeated invasive procedures and significantly worsens the patient's quality of life. In addition, increased demands for the provided health care and financial costs negatively impact the complications.

Conclusion

In our study, we sought to determine the potential advantages of PNB over LIA in AVF formation. The results of our small cohort suggest that the use of PNB could improve fistula functionality at 6 weeks and 1 year postoperatively versus LIA. It seems that

the use of this method also shortens the duration of the operation due to the improved conditions for the operator. This is probably due to the vasodilatation of the vessels used to create the AVF, which persists for some time even in the postoperative period and improves the flow in the newly created AVF in the first critical hours after the operation. No major conclusions can be drawn from our small sample. Large randomized trials are needed for definitive conclusions, some of which are currently underway and their results may influence future clinical practice.

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