## **Review Article**

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## The importance of anesthesiological methods in the creation of arteriovenous fistulas

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### **ABSTRACT**

All anesthesia procedures represent a real danger to life in patients with renal insufficiency, which is why these patients are classified in category IV, so anesthesia procedures for this population are adjusted depending on their individual characteristics. Although local and general anesthesia are acceptable modalities for arteriovenous fistula formation, it is known that local anesthesia is associated with tissue reduction and edema, which may be associated with reduced electrocautery efficiency, increased risk of infection, and vasospasm, especially with repeated injections. It must be noted that there is no consensus on whether an arteriovenous fistula should be created under local, regional, or general anesthesia. Still, it is considered that regional block anesthesia provides reduced vasospasm of blood vessels, provokes venodilatation and complete sensory and blockade of motor neurons, as well as higher primary functional rates in the first 3 months, since its creation, compared with local anesthesia. Overall, patients with end-stage renal disease are a group of patients with a wide range of comorbidities which, along with chronic kidney damage, increase the risk of perioperative anesthetic complications, especially when subjected to general anesthesia. Therefore, alternative modes of anesthesia, such as local and regional blockade, could bring obvious benefits to these patients. It can be concluded that the choice of anesthesia method is determined by several interrelated factors, anesthesiologist, patient and the surgeon, which implies expertise, inclination, habits, practicality, and norms.

Keywords: Anesthesiology, Arteriovenous fistula, Local anesthesia, Regional block anesthesia, General anesthesia

### **INTRODUCTION**

The number of patients with terminal renal failure in the world is constantly increasing, and the estimated annual material costs per patient for their medical care reach 180.000 dollars. Arteriovenous fistulas are the preferred model of the vascular access for the treatment of chronic hemodialysis. Compared with tunneling central venous catheters and vascular grafts, arteriovenous fistulas have a lower risk of systemic sepsis and of all causes of cardiovascular mortality. There was a significant initial rate of early complication of radiocephalic arteriovenous

fistulas, due to thrombosis, inadequate blood flow and/or insufficient maturation. Interventions to maintain vascular access to hemodialysis cost \$600 million annually in the United States. Fistula maturation is associated with significant preoperative (arterial and venous diameter) and postoperative (blood flow through arteriovenous fistulas) parameters, patient characteristics, and surgical techniques. Therefore, a large number of research efforts are focused on these factors to improve the patency rate of the fistula. <sup>1-6</sup>

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It has long been thought that anesthesia techniques can affect the rate of blood flow through arteriovenous fistulas and the success rate.<sup>6</sup>

It must be pointed out that all anesthesia procedures represent a real danger to life in patients with renal insufficiency. Therefore, the American Association of Anesthesiologists has classified patients with end-stage renal disease in category IV, along with severe systemic diseases, so anesthesia procedures for this population are adjusted depending on their individual characteristics.<sup>7,8</sup>

#### PHARMACOKINETICS OF DRUGS

The interaction between end-stage renal disease and anesthetic drugs depends not only on renal excretion but also on the pharmacokinetics of the drug. Due to permanent hypervolemia in these patients, there is a reduced concentration of plasma proteins, which are therefore less available for drug binding and transport. The degree of drug ionization will also be affected by chronic metabolic acidosis, which in combination with hypoalbuminemia and low plasma proteins increases the concentration for those drugs that have a higher affinity for protein binding.<sup>9</sup>

In patients with end-stage renal disease, the pharmacokinetics of the drug are altered, especially anesthetics (Table 1), therefore the doses of thiopental and benzodiazepines should be reduced by 30-50%. The pharmacokinetics of propafol do not change in renal failure, but there is some evidence to suggest that patients with established renal insufficiency require higher initial doses to achieve the same level of hypnosis. This must be balanced with frequent cardiovascular comorbidities and patient instability. Inhaled agents are ideal for maintaining general anesthesia, because they are excreted through the lungs. As most opioids are metabolized in the liver, renal disease is not considered to affect the pharmacokinetics and dynamics of drug administration. However, morphine has active metabolites (morphine-6glucuronide) that are excreted by the kidneys and are prone to accumulation and toxic effects, so doses should be reduced or alternatives found. Oxycodone is widely used in patients with impaired renal function, because the prolongation of the effect that can be attributed to the accumulation in renal insufficiency is much less pronounced. Fentanyl's rapid onset and deviation combined with the lack of active metabolites makes it more suitable for postoperative use if necessary. Suxamethonium may cause an increase in serum potassium, which should be taken with caution in these patients who already show relative hyperkalemia. Most non-depolarizing muscle relaxants are excreted unchanged by the kidneys, so doses should be reduced. Rocuronium relies in part on renal excretion and as such shows prolonged action in renal failure.<sup>9</sup>

Local anesthetics are extremely useful drugs in surgical interventions in patients with chronic renal failure. In end-stage renal disease, metabolic acidosis reduces both the duration of anesthetic action and plasma protein binding, which increases the possibility of toxicity, so maximum doses must be reduced by 25%. Esters are hydrolyzed in plasma, while amides undergo liver metabolism, so renal excretion does not affect their function. Performing neuroaxial blockade and possibly peripheral regional blocks may be contraindicated, which in turn may pose an increased risk for patients in need of general anesthesia.<sup>9</sup>

# INFLUENCE OF TYPE OF ANESTHESIOLOGICAL TECHNIQUE ON CREATING AN ARTERIOVENOUS FISTULA

Species of anesthesia used to create arteriovenous fistulas can play an important role in the maturation and longterm patency of an arteriovenous fistula. In addition to demanding general anesthesia, recommended only in special circumstances, other anesthesia techniques are available for the creation of arteriovenous fistulas. The use of local anesthesia is an extremely desirable method, which does not require the mandatory presence of an anesthesiologist, which is why the formation of a vascular access can be organized on an outpatient basis. Local anesthesia is associated with tissue reduction and edema, which may be associated with reduced electrocautery efficiency and increased risk of infection. Variable degrees of vasospasm also occur during this procedure, especially with repeated injections. Yet, it is common for anesthesia to be chosen by the operating surgeon, regardless of the effect that anesthesia may have on the degree of maturation. 10

## INFLUENCE OF ANESTHESIA ON SYSTEMIC CIRCULATION

Regional block anesthesia provides reduced vasospasm of blood vessels, provokes venodilatation and complete sensory and blockade of motor neurons in the area distal to the middle upper arm. A prospective study evaluated the effect of the axillary nerve block for site selection to create an anastomosis and found an increase in the rate of initial functioning of the arteriovenous fistula when regional blockade due to consecutive venodilation is used. Complications associated with regional block anesthesia include pneumothorax. hematoma. intravascular, epidural, or subarachnoid injection, and rare nerve damage. Side effects include temporary paralysis of the phytin nerve and Horner's syndrome. A unilateral block of the phrenic nerve is unlikely to create a problem if the patient does not have a respiratory disease. The benefits of regional block are well documented and include anesthesia of the entire upper extremity, block of motor function during the procedure, and venodilation. Regional block, unlike local anesthesia, results in reduced tissue edema resulting in improved electrocautery efficiency and reduced risk of infection. A review of the literature published in 2009. indicates better postoperative analgesia and faster recovery from anesthesia. Shorter time for surgery and reduced intraoperative pain are also observed, compared to local anesthesia. Arterial vasodilation occurs due to sympathetic block with subsequent reduced resistance and improved blood flow through the upper arm. Long-term effects are unknown, however, associated venodilation, as a consequence of regional block anesthesia, has been shown to last over five hours. Increased blood volume through the extremity and perioperative venodilatation, even if short-lived, may play an important role in the early remodeling of a newly formed fistula. Venodilation after brachial plexus block can provide an accurate estimate of vein diameter, during the operation itself. 9,10

In a study by Reynolds et al. the application of regional block anesthesia increased the rate of initial arteriovenous fistula function from 89% to 93%. The long-term effects of brachial plexus blockade on fistula patency are unknown, but a tendency of the venous conduit of the arteriovenous fistula to form an aneurysm has been established.<sup>10</sup>

Although local, general or regional anesthesia are acceptable modalities for arteriovenous fistula formation, the accumulation of evidence suggests that regional anesthesia in the form of a brachial plexus block is associated with significantly increased blood flow through the arteriovenous fistula as well as higher primary functional rates in the first 3 months compared with local anesthetic infiltration. 9,10

## INFLUENCE OF ANESTHESIA ON THE LENGTH OF FUNCTIONING OF ARTERIOVENOUS FISTULAS

Meta-analysis data show that regional anesthesia results in a significantly better patency rate of arteriovenous fistulas, compared to local anesthesia. Although it is generally accepted that radiotherapy of brachiocephalic arteriovenous fistulas is necessary for between 4 and 6 weeks. Only two studies had an adequate methodology for recognizing late complications of arteriovenous fistulas, while the remaining studies, methodologically, only assessed the early post-operative period. There is no consensus on whether an arteriovenous fistula should be created under local, regional, or general anesthesia. Patients with end-stage renal disease are a group of patients with a wide range of comorbidities and usually have underlying coronary artery disease, diabetes mellitus, chronic obstructive pulmonary disease, and hypertension. All of these comorbid conditions, along with chronic kidney damage, increase the risk of perioperative anesthetic complications, especially when subjected to general anesthesia. Therefore, alternative modes of anesthesia, such as local and regional blockade, could bring obvious benefits to these patients. In regional anesthesia, a targeted injection of a local anesthetic is performed to block the motor and sensory nerves that innervate the operative site. This model of anesthesia results in venous dilatation and sympatholytic effects, that is, an increase in diastolic blood flow and a decrease in peripheral arterial resistance Aitken et al measured blood flow through the brachial artery before and immediately after anesthesia. <sup>11</sup> They found that regional, unlike local anesthesia, was associated with increased blood flow through the brachial artery. Moukuet et al indicated a significant increase in blood flow in the brachial artery after block anesthesia, compared with local anesthesia. <sup>12</sup>

Shoshiashvili et al performed randomized local and regional block anesthesia in 103 patients and found that regional anesthesia was associated with significantly shorter operative times and lower analgesic needs. 13 The supraclavicular regional technique blocks both the ulnar and musculoskeletal nerves, which increases the rate of functionality compared to interscalenic and axillary approaches. Moreover, when performed under ultrasound control, this procedure appears safe, with a low rate of complications, such as toxicity from local anesthetics, direct nerve injury, pneumothorax, and hematoma. Rare but serious complications can occur, especially when the local anesthetic solution is inadvertently injected into a blood vessel or absorbed in high doses, which can result in systemic neurotoxicity or cardiotoxicity. Local anesthesia is performed without guidance, can be complicated by accidental nerve perforation and result in vasospasm or hematoma formation. This risk is higher in obese patients with deeply located veins.<sup>6</sup>

### REGIONAL BLOCK OR LOCAL ANESTHESIA

Systematic review and meta-analysis from four singlecenter randomized controlled trials showed that the use of regional block anesthesia for arteriovenous fistula surgery was associated with improved fistula functionality, compared with local anesthesia. Administration of regional block anesthesia requires the presence of an appropriately trained anesthesiologist and lasts longer than local anesthesia. Although the available evidence suggests that regional block anesthesia is useful, only large multicenter randomized controlled trials can provide sufficient evidence to change guidelines and practice. Renal Association Clinical Practice Guideline on Haemodialysis for vascular access to hemodialysis do not include recommendations on anesthesia technique, and recent European Society of Vascular Surgery guidelines recommend that regional block anesthesia be primarily recommended for local anesthesia, level of evidence B. Barriers to the use of brachial plexus block versus local anesthesia, as research and qualitative findings show, including surgeon's decision, time constraints and lack of anesthesiologists to perform block anesthesia, shifts toward regional anesthesia, appear to be facilitated by the perception of improved outcomes, with anesthesiologists often recognized as drivers of these changes. The choice of anesthesia modality shows the complexity of anesthesia as an intervention and that the choice of anesthesia method is determined by several interrelated factors that include not only the anesthesiologist, but also the patient and the surgeon. Decisions about the mode of anesthesia depend on a number of interrelated factors, including expertise, inclination, habit, practicality, and norms.<sup>14</sup>

# ANESTHETIC METHODS FOR CREATING ARTERIOVENOUS FISTULA: STILL THERE IS NO CONSENSUS

The most commonly used local anesthetics belong to the group of amino esters and amino amides, and they all

cause blockade of nerve impulses. By adding vasoconstrictors (adrenaline, phenylephrine) their effect and duration is prolonged. The regional anesthesia technique allows for less hemodynamic variation and reduces the risk of aspiration. Analgesic sedation increases the risk of apnea, aspiration and hypoxia and therefore the anesthesiologist must always be prepared to translate regional anesthesia into general. To create an arteriovenous fistula, the most commonly used are: infiltration of a local anesthetic, blockade of peripheral nerves, blockade of the brachial plexus and axillary block anesthesia.

Table 1: Characteristics of individual anesthetics used in infiltrative anesthesia. 17

Types of the drug	Common concentrations	Ordinary solution		Epinephrin	Epinephrine-containing solution	
		Maximum doses (mg)	Duration of anesthesia (r	Maximum doses (mg)	Duration of anesthesia (min)	
Estri						
Procain	1.0	1000	30-60		•	
Chlorprocain	1.0-2.0	800	30-45	000	30-90	
Amidi					•	
Lidocain	0.5-2.0	300	30-120 5	500	120-360	
Mepivacain	0.5-1.0	300	45-90 5	500	120-360	
Prilocain	0.5-1.0	500	30-90 <i>6</i>	500	120-360	
Bupivacain	0.25-0.5	175	120-240 2	225	180-420	
Ropivacain	0.2-1.0	300	360-600 I	Not used		
Etidocain	0.5-1.0	300	120-180	100	180-420	

In most institutions, local anesthesia is used to create arteriovenous fistulas in the area of the wrist and forearm (Table 1). This procedure is often supplemented application with intravenous narcotics from the group of barbiturates or benzodiazepines, which can cause complications, which in the postoperative course prolong their recovery in the intensive care unit. <sup>16</sup>

The musculocutaneous and medial antebrachial nerves of the skin can be anesthetized by peripheral infiltration, the so-called blockade of peripheral nerves. This technique is well accepted for the creation of an arteriovenous fistula in the forearm region, it is relatively easy to perform, and the need for high doses of local anesthetics is avoided. Brachial plexus block in the supraclavicular region is a procedure used for planned surgery on the upper extremity, any region. This anesthesia is limited to patients who can move their arm by 900, but often requires additional infiltration of local anesthetics, especially for the upper arm. Complications that may occur after the application of block anesthesia are hematoma, nerve damage, perforation of blood vessels, pneumothorax and arteriovenous insufficiency. 15-17

### **CONCLUSION**

All anesthesia procedures represent a real danger to life in patients with renal insufficiency, therefore it is necessary to plan and adapt them to their condition. It is important to know the pharmacokinetics of drugs used in anesthesia as well as all anesthetic techniques used in patients with end-stage kidney disease. In addition to very demanding general anesthesia, local anesthesia is an extremely attractive method, so be the formation of a vascular access can be organized on an outpatient basis. Local anesthesia is associated with tissue reduction and edema, which may be associated with reduced electrocautery efficiency and increased risk of infection. Regional block anesthesia provides reduced vasospasm of blood vessels, provokes venodilatation and complete sensory and blockade of motor neurons, which affects the increase in flow rate, and of initial functioning of the arteriovenous fistula. Yet, there is still no consensus regarding the application of the anesthesia technique for creating an arteriovenous fistula. It can be concluded that the choice of anesthesia method is determined by several interrelated factors, anesthesiologist, patient and the surgeon, which implies expertise, inclination, habits, practicality, and norms.

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