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Comparison of the Effects of Inhalation and Spinal Anesthesia on Microcirculation in Transverse Rectus Abdominis and Gluteus Maximus Muscle-Skin Flap Applications in Experimental Rat Models

Deneysel Siçan Transvers Rektus Abdominis Ve Gluteus Maksimus Kas-Deri Flep Modellerinde Inhalasyon Ve Spinal Anestezinin Mikrodolaşima Etkilerinin Karşılaştırılması

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ABSTRACT

Background: Alongside developments in the surgical approaches to flap dissections, significant advances have been seen also in anesthetic techniques, as one of the main factors in the performance of such interventions. Literature contains several clinical studies aiming to determine the optimum anesthetic technique for use in flap and microsurgical procedures, however there is still a lack of consensus on the ideal anesthetic technique. The present study compares experimentally the effects of inhalation and spinal anesthesia on different muscle-skin flaps during flap surgery.

Methods: The study assigned 35 rats to five groups: Group 1) a control group with no ischemia induced; Group 2) undergoing an elevated transverse rectus abdominis muscle-skin flap under inhalation anesthesia; Group 3) undergoing an elevated transvers rectus abdominis muscle-skin flap under spinal anesthesia; Group 4) undergoing an elevated gluteus maximus muscle-skin flap under inhalation anesthesia; and Group 5) undergoing an elevated gluteus maximus muscle-skin flap under spinal anesthesia. After the experiment, the malondialdehyde, total antioxidant capacity and total oxidative stress values were measured. Specimens were taken for histopathological examination to assess hyalinization, inflammation, congestion, edema, hemorrhage, nuclear centralization, and fibrotic areas.

Results: Inflammation, congestion and edema were significantly higher in Groups 2 and 4 than in the other groups.

Conclusion: In the light of the study findings, it can be concluded that regional anesthesia is the preferable anesthetic method in flap procedures, since inhalation anesthesia has an oxidative effect on both transvers rectus abdominis and gluteus maximus muscle-flap models, while such effects are lower with spinal anesthesia.

Keywords: inhalation, spinal, anesthesia, muscle-skin flap

ÖZET

Amaç: Flep disseksiyonları sırasında kullanılan cerrahi tekniklerdeki gelişmelerle birlikte, bu tip girişimlerin yapılabilmesi için en önemli koşullardan biri olan anestezi tekniklerinde de önemli gelişmeler olmuştur. Literatürde, flep ve mikrocerrahi uygulamalarında kullanılabilecek en uygun anestezi tekniğinin belirlenebilmesi amacı ile yapılan birtakım klinik çalışmalar mevcuttur. Bu çalışmada, flep cerrahisi sırasında inhalasyon ve spinal anestezinin, farklı kas-deri fleplerindeki etkilerinin deneysel olarak karşılaştırılması amaçlanmıştır.

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Metod: Çalışmada 35 adet sıçan beş eşit gruba ayrıldı. Grup 1) iskemi oluşturulmayan kontrol grubu; Grup 2) inhalasyon anestezisi altında transvers rektus abdominis kas-deri flebi kaldırılan grup; Grup 3) spinal anestezi altında transvers rektus abdominis kas-deri flebi kaldırılan grup; Grup 4) inhalasyon anestezisi altında gluteus maksimus kas-deri flebi kaldırılan grup ve Grup 5) spinal anestezi altında gluteus maksimus kas-deri flebi kaldırılan grup olarak planlandı. Tüm gruplarda 0, 7, 14 ve 28. günlerde perkütan yolla flep O_2 satürasyonları ölçüldü. Deney sonunda malondialdehit, total antioksidan kapasitesi ve total oksidatif stres değerleri ölçüldü. Histopatolojik inceleme için alınan örneklerde hiyalinizasyon, inflamasyon, konjesyon, ödem, kanama, nükleer santralizasyon ve fibrozis alanları değerlendirildi.

Bulgular: İnflamasyon, konjesyon ve ödem parametre bulguları Grup 2 ve 4'te, diğer gruplara kıyasla anlamlı derecede yüksek saptandı.

Sonuç: Çalışmadan elde edilen bulgular sonucunda, flep uygulamalarında rejyonel anestezi yöntemlerinin tercih edilebilecek bir anestezik yöntem olduğu düşünülebilir, çünkü inhalasyon anestezisi hem transvers rektus abdominis hem de gluteus maksimus kas flep modellerinde oksidatif etkiye sahipken, spinal anestezi ile bu etki daha düşüktür.

Anahtar kelimeler: İnhalasyon, spinal, anestezi, kas-deri flebi

1. INTRODUCTION

Flaps are commonly used in plastic and reconstructive surgery for the repair of tissue defects occurring due to various etiologies, such as trauma or tumor excision (Nahai et al., 1984; Taylor et al., 1994; Özdemir et al., 2017; Mathes et al., 1977; Costa et al., 2012). In flap surgeries, the success of operation is dependent upon the experience of surgeon, as well as technical factors. The most common issues affecting flap success include hemodynamic instability, flap ischemia and necrosis (Schusterman et al., 1992). Ischemia related to microcirculatory disorders is usually a result of incorrect planning or insufficient tissue perfusion (Sigurdsson et al., 1995). The anesthetic technique of choice is another important parameter affecting microcirculation, as a poor choice can lead to insufficient tissue perfusion, regardless of the surgical technique (Hagau et al., 2009).

General anesthetic techniques are often used in muscle-skin flap operations but may vary based on the characteristics of the reconstruction site and the flap to be used (Laha et al., 2013; Banic et al., 1999; Demirag et al., 2006; Bruegger et al., 2002; Jayaram et al., 2018). It is known, however, that general anesthesia has a greater effect on hemodynamic parameters than regional anesthesia, and so there has been a growing tendency to look for alternative anesthetic options (Barker et al., 1990). Previous studies have analyzed the effects of general anesthetic agents on regional blood flow, although the effects of spinal anesthesia on microcirculation have yet to be fully established (Turek et al., 2009). This experimental study aims to determine the effects of inhalation and spinal anesthetic techniques on flap microcirculation in a composite muscle-skin flap rat model, based on flap monitorization and postoperative biochemical and histopathological assessments. It is believed that the findings from the present study will contribute to literature identifying the ideal anesthesia for circulation during flap surgery, which has a wide area of application in plastic surgery procedures.

2. MATERIALS and METHODS

Prior approval for the study was granted by the Dicle University Faculty of Medicine Local Ethics Committee Department (dated June 10, 2010, and No: 2010/13). The study included 35 male isogenic Sprague-Dawley albino rats, which selected according to statistical calculations. The rats weighing 250–300 g, which were acquired from the Dicle University Prof. Dr. Sebahattin Payzın Experimental Research Center (DÜSAM). Rats were kept collectively in standard cages and fed with standard pellet [TAVAS Inc, Adana, Turkey], while water needs were met through standard methods. The rats were kept in the lab at a stable 21°C in a 12-hour day and 12-hour night lighting cycle. The humidity level in the room was kept stable at 45±10%. All the procedures were carried out by a single researcher.

2.1. Experimental Groups

The rats were assigned to five separate groups, with seven rats in each group, using a digital randomization program. Group 1 was the control group and underwent no procedure. Group 2 underwent an elevated transvers rectus abdominis muscle-skin (TRAM) flap under inhalation anesthesia; Group 3 underwent an elevated TRAM muscle-skin flap under spinal anesthesia; Group 4 underwent an elevated gluteus maximus muscle-skin flap under inhalation anesthesia; and Group 5 underwent an elevated gluteus maximus muscle-skin flap under spinal anesthesia.

2.2. Surgical Method

The rats were first administered anesthesia with intramuscular ketamine hydrochloride 30 mg/kg [Ketalar®, Eczacibasi AS, Luleburgaz, Turkey] and 2% xylazine (10 mg/kg) [Rompun® DS, Bayer AG, Leverkusen, Germany], and cefazolin sodium (0.25 g) [Sefazol®, Mustafa Nevzat AS, Istanbul, Turkey] was administered intramuscularly for surgical prophylaxis. An external jugular vein polyethylene catheter (PE-10; i.d 0.28 mm and o.d 0.61 mm) [Becton Dickinson, Phi, USA] was used for cannulation. Ringer's solution (5 ml/kg/hour) was administered through this route

as a continuous intravenous infusion. Body temperatures were kept at 35–37˚ C using an electric heater.

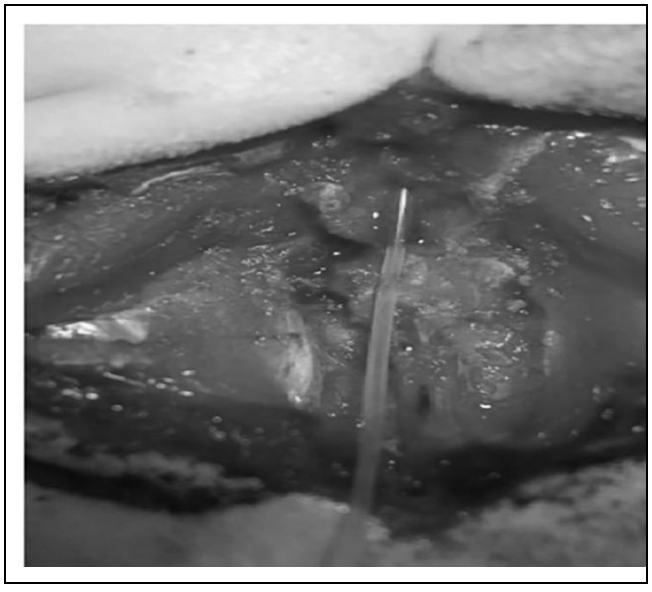
2.2.1. Method of inhalation anesthesia

Oral intubation was performed through a small-sized laryngoscope, and a volatile anesthetic solution was administered using a standard vaporizer [Ohmede, BOC Healthcare, West Yorkshire, UK]. Isoflurane (2MAC) [Abbott, Wiesbaden, Germany] was used as the agent.

2.2.2. Method of spinal anesthesia

The spinous processes of the lumbar vertebrae on the back of the rats were palpated and a midline incision was made to expose the paravertebral fascia. Following the fascial midline incision, a blunt-sharp dissection was made using an elevator to separate and exclude the paravertebral muscles, and the L4-L5 vertebral bodies were exposed. The spinous processes were shaved, and the midline was punctured. The dura was exposed, and the incision was advanced using forceps with a pointed tip until cerebrospinal fluid (CSF) was seen to leak. Spinal cannulation was then performed through the CSF-leaking area using a 200 mm long polyethylene catheter (PE-10; i.d. 0.28 mm and 0.61 mm) [Becton Dickinson, Phi, USA] (Figure 1). The catheter was advanced 10–15 mm towards the cervical direction and fixed to the proximal spinous process with a 4/0 polyglactin [Vicryl®, Ethicon, Johnson & Johnson, Norderstedt, Germany] suture. Hamilton 100 μL gas-tight syringes were advanced 15 mm through the polyethylene tube using a 28-gauge needle. An injection of 2% lidocaine [Aritmal®, Osel İlaç San ve Tic AŞ, Istanbul, Turkey] 25 μL solution was administered (Acar et al., 2013).

Figure 1: Polyethylene tube insertion below the dura



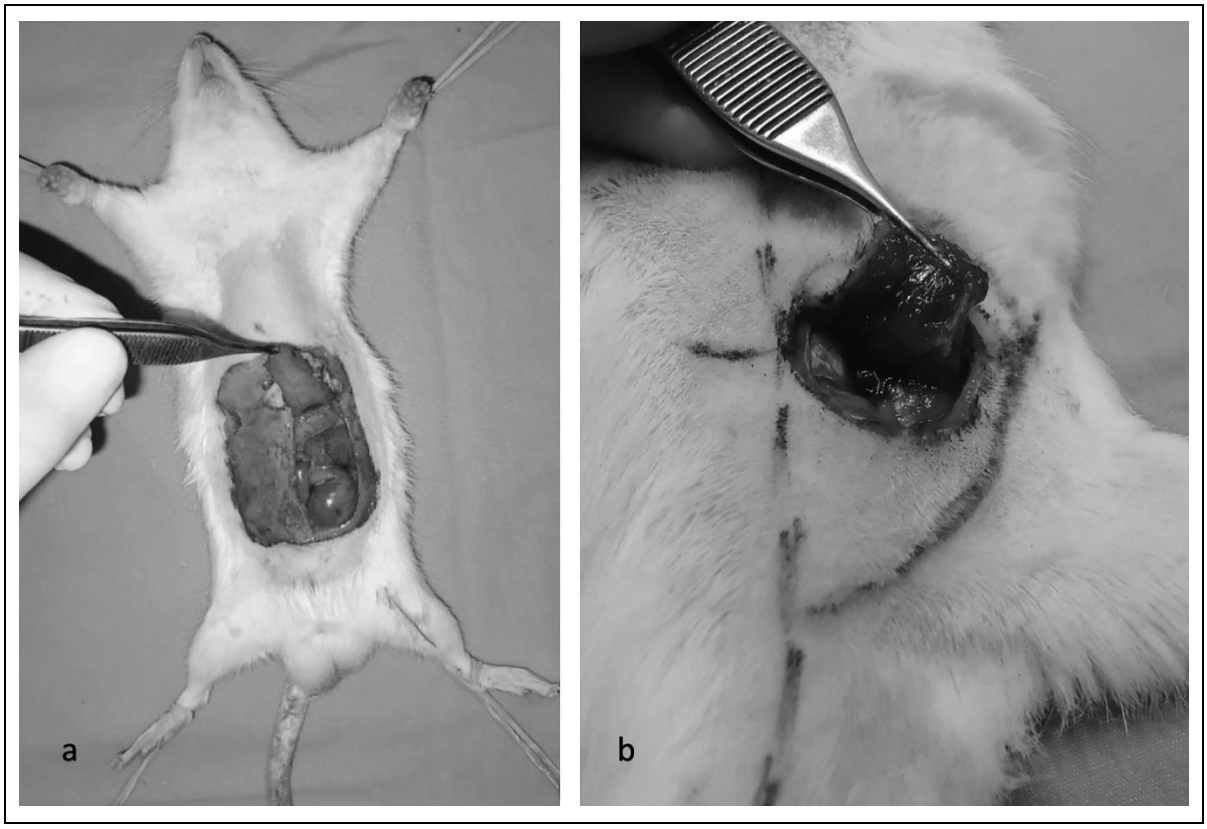
The other end of the polyethylene tube was taken out from the back of the ear through a subcutaneous tunnel created with a blunt-sharp dissection. Following catheter insertion and fixation, the hole in the vertebral bone was closed using a fibrin matrix [Tisseel®, Eczacıbaşı-Baxter Ltd Şti, Istanbul, Turkey]. The paravertebral muscles and fascia were sutured closed for primary intention with a 5/0 polyglactin [Vicryl®, Ethicon, Johnson&Johnson, Norderstedt, Germany] suture.

The rats were assessed postoperatively for neurological disturbances.

2.2.3. Elevation of the TRAM muscle-skin flap

The rectus muscles were marked on both sides of the abdominal midline on the vertical plane, along with the vertical length of the island flap using two horizontal lines, 2 cm above the pubis and 1 cm below the xyphoid. The island flap was marked as 4x4 cm to ensure it exceeded the rectus muscle by a minimum 2 mm bilaterally. The island flap was incised on all sides, and the thin fascia layer was accessed via the abdominal muscles around the island flap, paying attention to ensuring that the island flap was not separated from the underlying muscle layer. For this purpose, the skin was fixed to the underlying muscle layer with an 8/0 polyglactin [Vicryl®, Ethicon, Johnson & Johnson, Norderstedt, Germany] suture. After the muscle was accessed, the linea alba was cut with longitudinal blunt and sharp dissections and the rectus muscle was dissected. The dissection continued with a cut to the rectus muscle 1 cm above the pubis, and the cauterization of the inferior epigastric veins. The dissection was completed upon reaching the sternum after cutting and separating the lateral thin vascular connections and intercostal nerves, resulting in an elevated muscle-skin flap with a superior pedicle (Figure 2a). The donor site was sutured by primary intention with a 4/0 polyglactin [Vicryl®, Ethicon, Johnson&Johnson, Norderstedt, Germany] suture. The island flap was then inserted into its former position and sutured using a 4/0 polyglactin [Vicryl®, Ethicon, Johnson & Johnson, Norderstedt, Germany] suture.

Figure 2: a) Elevation of the TRAM muscle-skin flap **b)** Elevation of the gluteus maximus muscle-skin flap



2.2.4. Elevation of the gluteus maximus muscle-skin flap

The projections of the vertebral and gluteus maximus were marked on the skin. An island flap measuring 4x4 cm, covering completely the gluteus maximus muscle, was marked. It was deepened until the all-round muscle plane underlying the island flap, and the incision line was extended over both ends of the ellipse. A blunt dissection was then made to access the underside of the gluteus maximus muscle, and the muscle was elevated from the pedicle (Figure 2b). Afterwards, the muscle was inserted into its anatomical position and the island flap was sutured using a 4/0 polyglactin [Vicryl®, Ethicon, Johnson & Johnson, Norderstedt, Germany] suture.

During anesthesia, vital signs, such as electrocardiogram, pO_2, pCO_2 and respiratory rate, were monitored. After the surgical procedure, the rats were isolated in single cages to prevent damage to the surgical site by other rats. The normal diet of the rats was continued after surgery.

The rats were checked daily and taken into collective cages on postoperative day 7; no restriction was applied, and free movement was permitted inside the cages.

After the operation, a percutaneous saturation probe was inserted into the abdominal region in all groups, and oxygen saturation was measured on days 0, 7, 14 and 28.

2.2.5. Biochemical assessment

After the experiment, all subjects were sacrificed upon intracardiac blood collection, and the blood samples were used to measure malondialdehyde (MDA), total antioxidant capacity (TAC) and total oxidative stress (TOC) levels. The serum level of MDA, one of the final products of lipid peroxidation, was determined using Beuge's method (1978). TAC and TAO levels were measured using Erel's method (2004).

2.2.6. Histopathological assessment

Biopsies were taken in a way to include both muscle and skin, 1x1 cm in size, at the midpoint of the flaps, in a standard manner for all rats. The biopsy specimens for pathological assessment were kept in 10% formaldehyde solution for fixation, and then embedded in paraffin blocks. Sections 5 µm in thickness were taken from the prepared paraffin blocks using a microtome. A series of 10 sections were taken from each rat and stained with hematoxylin-eosin (H&E) for histopathological assessments. The stained preparations were evaluated by a pathologist expert under light microscope [Nikon® ECLIPSE 80i, Japan]. The tissue sections (at x100 magnification) were used to assess hyalinization, inflammation, congestion, edema, hemorrhage, nuclear centralization, and fibrotic areas. The parameters were classified and scored as (+), (++), (+++) or (++++).

2.2.7. Statistical assessment

The researchers assessed the experimental groups double blinded when interpreting the findings. Descriptive statistics for continuous variables were presented as mean and standard deviation (SD). The five different groups were compared using a Kruskal-Wallis test. For variables with differences in group values, paired comparisons were made using a post-Hoc test or a Mann-Whitney U test with a Bonferroni correction to determine the source group of the difference. Hypotheses were evaluated as two-tailed. The statistical analyses were made using the SPSS IBM 25.0 for Windows [SPSS Inc., Chicago, IL, USA] software package. A p value of <0.05 was considered statistically significant.

3. RESULTS

None of the rats developed any deficits during the surgical procedures or follow-up, and all rats were included in the assessment.

There was no significant difference in the oxygen saturation measurement findings of the groups (p>0.5) (Table 1).

Table 1: Distribution of oxygen saturation values on days 0, 7, 14 and 28 by groups

		Mean	SD	Minimum	Maximum	F	p
0. day	1	93.50	2.121	92	95	.447	.772
	2	93.00	3.606	90	97		
	3	92.50	2.121	91	94		
	4	95.50	.707	95	96		
	5	93.50	.707	93	94		
7. day	1	94.50	2.121	93	96	2.084	.201
	2	92.33	2.517	90	95		
	3	96.00	1.414	95	97		
	4	96.50	.707	96	97		
	5	95.50	.707	95	96		
14. day	1	97.00	.000	97	97	2.897	.118
	2	94.67	1.528	93	96		
	3	91.00	1.414	90	92		
	4	94.00	2.828	92	96		
	5	94.50	2.121	93	96		
28. day	1	96.00	1.414	95	97	.368	.824
	2	95.67	4.041	91	98		
	3	97.50	.707	97	98		
	4	96.00	1.414	95	97		
	5	94.50	.707	94	95		

ANOVA test used.

SD; Standard Deviation

Biochemical analyses revealed MDA values to be significantly increased in Groups 2 and 4 when compared to the other groups (p=0.002). TAC values were significantly increased in Groups 3 and 5 when compared to the other groups (p=0.002). TOS values were significantly increased in Group 2 when compared to the other groups (p=0.01) (Table 2).

Table 2: Comparison of biochemical parameters between groups

	Groups	Mean	SD	F (ANOVA)	p	Bonferroni
MDA	1	3.45	0.84	12.71	<0.001	1-2; p=0.002 1-3; p=0.004 1-4; p=0.001 2-5; p=0.002 3-5; p=0.005 4-5; p=0.002
	2	11.05	4.31			
	3	10.33	2.43			
	4	10.47	2.05			
	5	2.66	0.75			
TAC	1	1.46	0.101	14.79	<0.001	1-2; p=0.024 1-5; p<0.001 2-4; p=0.023 3-5; p=0.002 4-5; p<0.001
	2	1.80	0.107			
	3	1.64	0.271			
	4	1.48	0.114			
	5	2.15	0.020			
TOS	1	254.0	66.65	4.03	0.017	2-4; p=0.015
	2	416.6	21.44			
	3	274.5	129.5			
	4	219.0	48.13			
	5	343.1	149.79			

MDA; Malondialdehyde

TAC; Total antioxidant capacity

TOC; Total oxidative stress

SD; Standard Deviation

Histopathological analyses revealed a significant difference in hyalinization between the control and experimental groups, with hyalinization found to be increased in the experimental groups (p<0.001) (Figures 3a,b). There was no significant difference in the hyalinization findings of the experimental groups (p>0.05). Findings of inflammation, congestion and edema were significantly higher in Groups 2 and 4 than in the other groups (p=0.0002). There was no significant difference in the rates of hemorrhage, nuclear centralization, or fibrosis in the experimental groups (p>0.05) (Graphic 1).

Graphic 1: The analysis results of the Kruskal-Wallis test for inflammation, congestion, edema, hemorrhage, nuclear centralization, and fibrosis

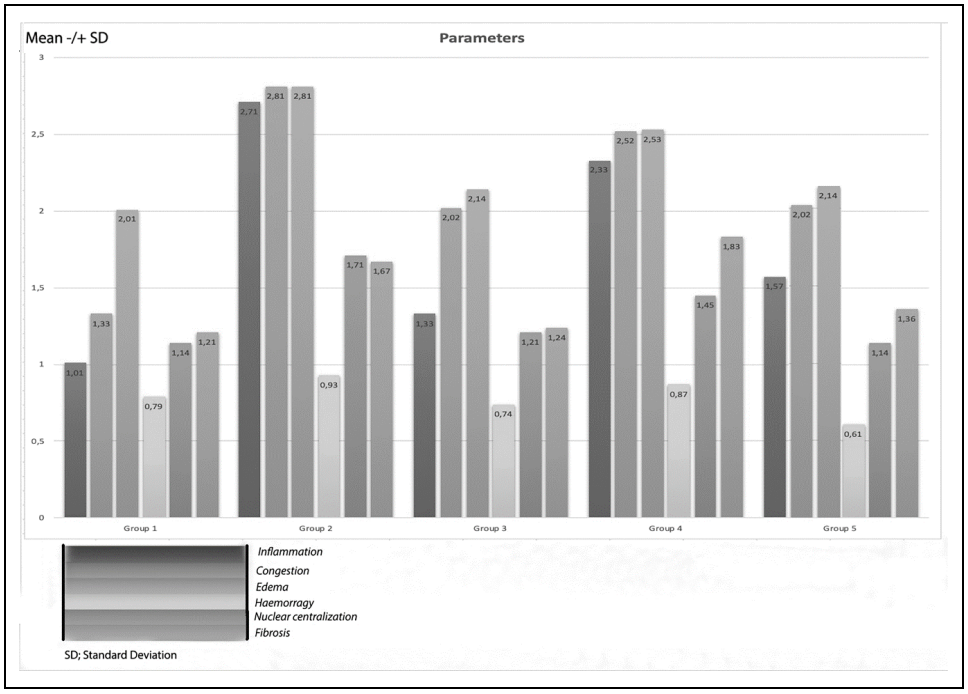
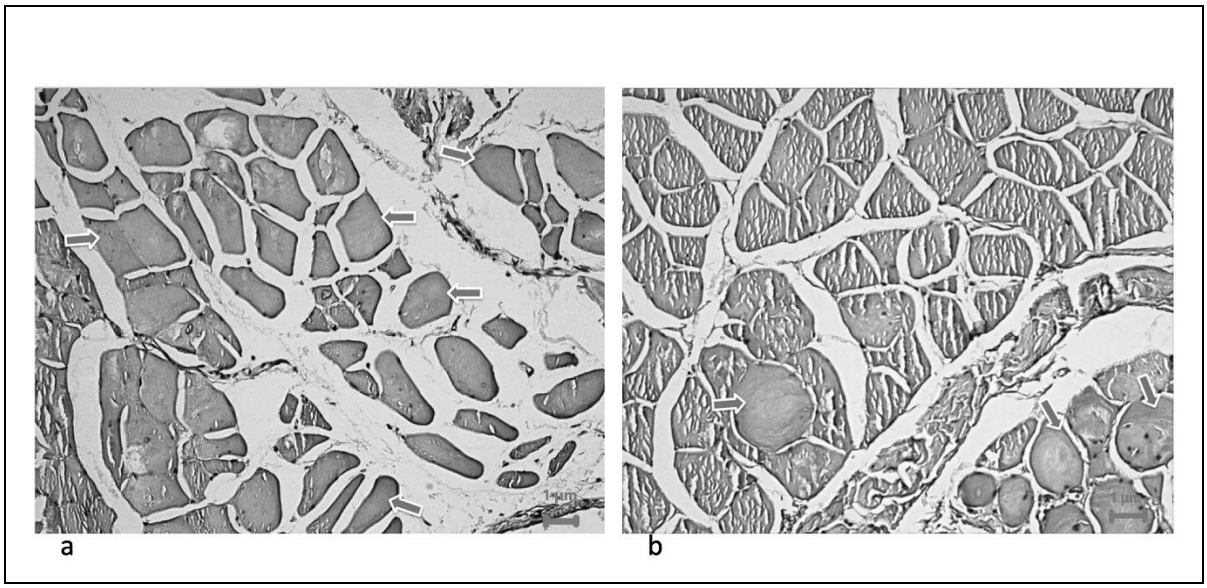


Figure 3: a) Appearance of diffuse hyalinization findings in striated muscle tissue in the experimental group (arrow: hyalinization) (H&E x100) **b:** Appearance of hyalinization findings in striated muscle tissue in the control group (arrow: hyalinization) (H&E x100)



4. DISCUSSION

Flap surgery is commonly used for the repair of tissue defects, and there are several factors affecting the outcome in interventions requiring microvascular surgery, such as flap surgery or replantation. Among these, the main factors include the age of the patient, the presence of systemic diseases, the surgical technique used and the experience of the surgeon, as well as the method of anesthesia used (Siemionow et al., 2004); Carroll et al., 2000; Ichioka et al., 2002; Uchida, 2000; Pereira et al., 2012; Huang et al., 2005).

Despite developments in surgical techniques, ischemia-reperfusion injuries (IRIs) are still an important issue in flap surgery. The surgical method used has been demonstrated to affect systemic and regional blood flow in the transferred tissue. Flap operations are extensive and sometimes long, and can lead to hypothermia, and progressive losses of fluid and blood, leading to vasoconstriction and thereby the loss of the flap (Nahai et al., 1984). Especially in composite flaps, hypoperfusion and necrosis are significant clinical problems, and anesthetic agents can also cause hemodynamic changes that can affect flap circulation. It is therefore believed that anesthetic methods that minimize vasospasm and reperfusion injury can lead to a reduction in IRIs (Halladin, 2015; Yang et al., 2019; Gyuraszova et al., 2018; Prior et al., 1999). Literature contains several studies investigating the minimization of postoperative IRIs, while there have been only limited clinical and experimental research to date analyzing the effects of anesthetic methods on IRI (Lazar et al., 2003; Wu et al., 2018; Blaisdell, 2002). We believe, therefore, that the present study presents information that can make a positive contribution to literature.

General anesthesia is usually preferred for flap surgery, although it depends on the localization and width of the surgical site. General anesthesia offers certain advantages, such as airway integrity, maintenance of ventilation in accordance with physiological conditions, sensitive control of anesthetic agent concentration through monitorization, the opportunity to make rapid changes to anesthetic levels, and rapid awakening (Corcoran et al., 2006). That said, the technique also comes with certain disadvantages, including postoperative symptoms such as nausea-vomiting, while in cases receiving inhalation anesthesia, blood flow can be reduced in the flap, negatively affecting flap viability (Ederer et al., 2020; Seal et al., 2011; Tujjar et al., 2017; Lee at al., 2020), and postoperative pain can lead to vasospasm (Lanz et al., 2001; Banic et al, 1997). For such reasons, flap perfusion may be adversely affected (Adolphs et al., 2004). It is known that the surgical response activates the hypothalamo-hypophyseal system during inhalation anesthesia, resulting in elevated levels of such hormones as catecholamines, adrenocorticotropic hormone (ACTH) and cortisol. Increased catecholamines, in turn, lead to vasospasm, and consequently, to reduced flap blood flow. As a result of such mechanisms, flap microcirculation may be impaired, and ischemia may occur (Turan et al., 2007).

The effects of general anesthetics on cardiac output, arterial blood pressure and regional blood flow have been documented, while the effects of spinal anesthesia on microcirculation in the transferred tissue have yet to be established experimentally (Costa et al., 2012; Schusterman et al., 1992; Carden et al., 2000). The present study evaluates the effect of anesthetic techniques on flap microcirculation, and thus it contributes to literature.

In the present study, biochemical parameters such as MDA, TAC and TOS levels are assessed to establish the severity of IRI. Among such molecules, MDA is the most appropriate parameter for level measurement as an indicator of lipid peroxidation (Carden et al., 2000). Accordingly, this

parameter was measured in the present study, and significantly higher levels of MDA were identified in the groups receiving inhalation anesthesia than in other groups. This finding suggests that inhalation anesthesia has a greater effect on flap hemodynamics and leads to microcirculatory changes, and so we recommend regional anesthesia for this type of operation in eligible cases.

Enzymatic and non-enzymatic antioxidants involved in preventing the formation of free oxygen radicals, in eliminating or suppressing the radicals that form, in breaking the radical chain reactions, in repairing or removing damaged target molecules, and in binding the metal ions can be listed generally under the heading of TAC (Lazar et al., 2003; Carden et al., 2000). The measurement of the antioxidant profile of the tissue based on the TAC determination can provide more valuable information than individual measurements of antioxidants, and recent studies have more often relied on TAC measurements as a result. The present study adopts the approach to TAC measurement developed by Erel (2004), which is currently accepted as the most reliable, allowing the sensitive measurement of total-SH, vitamin C, uric acid, vitamin E, bilirubin, and many other antioxidant molecules in the tissue (Huang et al., 2005; Halladin, 2015). The present study found significantly higher TAC levels in the spinal anesthesia group than in the other groups, which suggests that regional anesthetic methods negatively affect flap microcirculation, and perfusion to a lesser extent.

In the present study, TOS measurements were made to measure "oxidative stress". A statistical analysis of the TOS values revealed a significantly greater increase in the group undergoing TRAM flap elevation under inhalation anesthesia than in the other groups, which we concluded was associated with both the anesthetic technique and the wider elevated flap.

The present study monitored postoperative flap perfusion through the measurement of intravital oxygen saturation. All groups had sufficient levels of oxygen saturation, with no significant difference between them, which suggests that neither the inhalation nor spinal anesthesia approach substantially affected the flap perfusion, while the micro-level histopathological data allowed an elaboration of the study findings.

An analysis of the hyalinization findings among the histopathologically assessed parameters revealed a significant elevation in all experimental groups when compared to the control group. This is in line with previous studies in literature and can be attributed to the inflammation resulting from surgery.

An analysis of the data on inflammation, congestion and edema revealed a significant increase in parameters in the inhalation anesthesia groups when compared to other groups, which suggests that inhalation anesthesia affects hemodynamic parameters more, and has a negative effect on flap perfusion. The absence of a significant difference in the rates of hemorrhage, nuclear centralization and fibrosis suggests little influence on the flap.

The limitation of the study is that flap circulation couldn't be demonstrated intravitally at the microvascular level. In future studies, more detailed data can be obtained with intravascular staining methods and dynamic measurement methods. Our study can be considered as a preliminary study in this sense.

A review of literature uncovered no previous studies in which different anesthetic methods were applied on different flap models, as the focus of the present study, nor any studies investigating the effects of such anesthetic techniques on flap microcirculation. Previous experimental and clinical studies have shown that a sympathetic blockade with regional anesthetic methods can improve perfusion through vasodilation and can avoid vasospasm through the prevention of pain (Turan et al., 2007). In an experimental study by Lazar et al. (2003), it was demonstrated that spinal anesthesia administered via the thoracic region substantially increased microvascular perfusion in the distal portion of the gastric tube, and it was thus recommended that this technique be used for esophageal reconstructive surgery. Demirag et al. (2006), in turn, reported the pancreatic hypoperfusion induced by acute pancreatitis to be decreased with spinal anesthesia, and tissue damage to be alleviated. In the light of these findings, it can be stated that spinal anesthesia leads to vasodilatation due to sympathetic blockade in the nerve roots and prevents both intraoperative and postoperative vasospasm. The present study also supports the use of regional anesthesia, and shows that the mass of the elevated flap, aside from the anesthetic method used, also has an influence on microcirculation.

5. CONCLUSION

A literature review was unable to garner sufficient data on the effects of anesthetic methods on flap circulation, and the superiority of different methods over each other. The present study will permit the comparative evaluation of the effects of general and spinal anesthetic agents, which are known to influence flap microcirculation, on various flap models. Because of experimental microcirculation and flap studies are indicative for human studies, we believe that the present study will contribute considerable to the determination of ideal anesthetic approaches in all flap surgeries.

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