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Additional Criteria for Evaluating the Anaesthetic Effectiveness in Reconstructive and Plastic Surgery in Patients with Facial, Neck, and Chest Postburn Contractures

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Abstract. A rational anaesthetic approach in reconstructive and plastic surgery ensures adequate systemic hemodynamics and tissue perfusion, which contributes to good wound healing and has an important impact on the favourable outcome of the surgery. With this aim 56 patients aged 16 to 50 years old, who underwent skin plasty to eliminate post-burn contractures of the face, neck, and chest, were monitored. Surgical interventions were performed using different anaesthetic tactics: among 48.2% (27 patients) regional anaesthesia with cervical plexus and the third branch of the trigeminal nerve block was used, and among 51.8% (29 patients) reconstructive plastic surgery was performed under total intravenous anaesthesia with a combination of ketamine and fentanyl in age-appropriate dosages. Myoplegia was provided by using arduan. There were no anaesthesia-related complications during the surgery. Oxygen pressure in the soft tissues ($PtcO_2$) of the operated area was studied using a Clark-type sensor by transcutaneous contact polarography. Central T_1C (cheek area) and peripheral T_2C (subclavian area) temperatures were recorded by electrical thermometry, as well as the temperature of the affected area T_3C. Comparing the temperature gradients of the flaps at different stages of the perioperative period in different groups we found evidence of better microcirculation with regional anaesthesia than with total intravenous anaesthesia. The thermometry results did not contradict the values obtained during the first measurements, but only confirmed the assessment of the skin flap condition. This leads to fewer complications when using regional anaesthesia in the operated tissues compared to the use of other tested methods.
Keywords: contractures, anaesthesia methods, regional anaesthesia, oxygen pressure, flap plastic.

1. Introduction

Face and neck burns are frequent both in adults and children, which is a challenge for anaesthesiologists and surgeons because post-burn contractures of this localization leave not only a cosmetic defect but also lead to anatomical remodelling of the airways, reduction of tissue tropism and development of complications in the postoperative period [1]. Adequate anaesthetic tactics help to maintain systemic hemodynamics, tissue microcirculation and gas homeostasis during the perioperative period, which promotes better wound healing and is of great importance for the successful outcome of reconstructive and plastic surgery (RPS) [2].

S. N. Hayek et al. [3] 11etrospectiveely evaluated and concluded that removal of the contracture between *musculusmentalis* and *sternum* (mentosternal) did not allow quality intubation in the long term, which narrows the choice of anaesthetic tactics. S. Prakash and P. Mullick [4] from the Department of Anaesthesiology and Intensive Care at Safdarjang Hospital conducted a literature review on this topic and pointed out that a safer approach to providing upper airway patency in patients with moderate to severe neck contractures is to provide it when the patient is conscious. That is, priority is given to regional anaesthesia, but the anaesthesiologist should have a pre-planned intubation strategy.

In addition to anatomical defects, it is necessary to focus on the effect of anaesthesia on postoperative healing – the existing generally accepted prognostic criteria cannot always provide

timely evidence of microcirculation and perfusion disorders (especially in the surgical intervention zone) [5,6].

The introduction of new perioperative methods of hemodynamic monitoring of the operated area in RPS can provide more reliable and useful information on the effectiveness of anaesthesia in this type of surgery [7,8]. The continuous transcutaneous determination of tissue oxygen tension ($PtcO_2$) in a non-invasive way (using contact electrodes) enables to monitor oxygenation in the skin flap and in the operating field tissues, which is very important in early diagnosis of possible complications related to perfusion disturbances [9,10]. At the same time, L. M. Nystrom et al [11] conducted a prospective and multi-institutional study in which they state that percutaneous oximetry cannot be considered a reliable method for predicting complications associated with wound healing and could be since this method examines a relatively small area of the skin. But in the absence of a reliable prognostic test, specialists should still use all possible techniques and work on the elimination of modifiable risk factors to avoid complications, so this issue requires further consideration.

In reconstructive and plastic surgery, the assessment of the thermal gradient between peripheral and central temperature can be a useful control indicator in terms of maintaining adequate microcirculatory health, which affects the viability of tissues used during surgery [12-14]. It is worth noting that in the study of S. Kimura and W. Butt [15] from The Royal Children's Hospital in the paediatric population the indicators of temperature gradient and skin temperature should not be used as the only marker for assessing the condition of patients but were indicative in combination with the determination of serum lactate level and cardiac output index.

The abovementioned information predefines the relevance of the research on anaesthetics tactics and the assessment of microcirculatory trophic in the management of facial and neck contractures. The research aims to investigate the effect of anaesthesia methods used on the temperature gradient and oxygen tension in the soft tissues of the operated area with subsequent assessment of their informativity as prognostic criteria of postoperative complications in the elimination of facial, neck and thoracic contractures.

2. Materials and Methods

The research is non-experimental by methodology, descriptive-analytical by the nature of the information obtained, and prospective asynchronous by the ratio of study time. Fifty-six patients in this study, aged 16 to 50 years, were examined. All patients were informed about the aims and course of the research, and informed consent was obtained from all respondents for the use of medical data. The complex study was conducted using standardized instrumental methods, the applied scientific approach is approved in modern studies and recommended by international experience for extensive use.

The following types of dermal plastic surgery were performed on the subjects: cross-plasty – 18 surgical interventions, flap plasty – 15, combined plasty – 12, and free dermal plasty – 5. The average duration of the operations was within 136±15 minutes. Surgical interventions were performed using different anaesthetic approaches: among 48.2% (27 patients forming Group #1) regional anaesthesia with blockade of the cervical plexus and the third branch of the trigeminal nerve was used, and among 51.8% (29 patients forming Group #2) – reconstructive-plastic operations were performed under total intravenous anaesthesia with a combination of ketamine with fentanyl in the dosage appropriate for the age. Myoplegia was provided by using arduan. The adequacy of anaesthesia tactics was controlled by clinical monitoring indices, which included systolic (BP, mm Hg), diastolic (BP, mm Hg), mean arterial pressure (MAP, mm Hg), heart rate (HR, bpm), oxygenation ($SpO_{2,\%}$) and body temperature (T^o).

Mean arterial pressure was estimated by formula (1):

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$$MAP = (SP + 2*HBP)/3, \quad (1)$$

Oxygen tension ($PtcO_2$) in the base of the soft tissues of the operated area was studied perioperatively by transcutaneous contact polarography using a Clark-type contact sensor and performed on TCM-2 apparatus by "Radiometer" (Denmark) with continuous fixation of indicators. The control area of this monitoring was $PtcO_2$ determination distant from surgical intervention- in the subclavian area. $PtcO_2$ data were recorded before and after the functional test (FT). FT was based on perfusion with humidified 100% oxygen through a half-open mask system for 5 to 7 minutes. Data fixation was performed in 4 stages: before the operation in the ward (stage 1), during the surgical stage of anaesthesia (stage 2), during the main stage of the operation – flap fixation (stage 3) and at the end of the operation when patients woke up with spontaneous breathing (stage 4).

The temperature was measured with an electric thermometer TEMP-400 with the determination of central T_1C (cheek area) and peripheral T_2C (subclavian area) temperature, as well as T_3C flap area with subsequent determination of temperature gradient ($_{\Delta}T_1C$ – between T_1C and T_2C, $_{\Delta}T_2C$ – between T_1C and T_3C, $_{\Delta}T_3C$ – between T_2C and T_3C). All the above indicators were also recorded in the 4 steps mentioned earlier.

Then the performance of postoperative graft-related complications was evaluated, which included the following: flap necrosis, wound suppuration, sublaptic hematoma, and graft lysis.

Statistical processing of the results was performed on a personal computer on Microsoft software using Excel-2018. X_2 test, Pearson criterion, and Cox proportional hazards were used. Differences in the indicators at the $P<0.05$ significance level were considered significant.

3. Results

Following the data obtained, blood pressure, pulse, and saturation parameters in the patients of both groups were within the physiological limits during all periods of observation, as shown in the following Table 1. The physiological perioperative hemodynamic indices were the mean arterial pressure values between 70 and 110 mmHg, heart rate between 60 and 90 bpm, and blood oxygenation >95%.

Focusing on clinical anaesthesia adequacy control methods, there were no evident signs of ineffective protection of the patient from intraoperative exposure factors depending on the anaesthesia method, which indicates the absence of negative effects on systemic hemodynamics. No complications related to anaesthesia during the operation were observed.

Table 1. Changes in hemodynamic parameters depending on the method of anaesthesia and the stage of surgical intervention (M±m)

Groups	Metrics	Stages			
		1	2	3	4
Cervical plexus blockades (n = 27)	Mean arterial pressure, mmHg	88.1±2.4	84.7±1.3	85.5±3.1	84.1±4.5
	HR, bpm	72.7±2.8	68.8±2.1	73.5±3.9	77.3±2.9* ** ***
	SpO_2, %	97.9±0.3	97.6±0.1	97.7±0.3* **	96.3±0.1* **
TBA	HBP, mmHg	86.5±2.6	97.6±2.3	85.5±2.5	84.3±2.2

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(n = 29)	HR, bpm	72.9±1.8	80.7±2.9	85.3±3.7* $^{0\,00}$	84.0±3.5*
	SpO_2, %	96.9±0.3^{00}	98.2±0.2*^{00}	98.0±0.3*^{00}	96.9±4.4** ***

*Note: * – p < 0.05 compared to stage 1, ** – p < 0.05 compared to stage 2, *** – p < 0.05 compared to stage 3, 00 – p < 0.05 compared to cervical plexus blockade.*

Source: compiled by the author

The reaction of the local tissues from which the skin flap was formed was different depending on the anaesthesiologic tactics used, which is shown in Table 2.

Table 2. Changes in the values of tissue oxygen tension ($PtcO_2$), mm Hg) of the skin flap depending on the method of anaesthesia and surgical intervention (M±m)

Groups	**Research zones**	**Stages**							
		Before surgery		Surgery stage		Flap fixation		Surgery end	
		Pre-AF	Post-AF	Pre-AF	Post-AF	Pre-AF	Post-AF	Pre-AF	Post-AF
Cervical plexus blockades	Control	126.1± 4.2	295.6± 37.4	123.3± 4.0	247.9± 41.0	115.4± 4.5*	231.1± 26.4	112.13. o * **	244.8± 27.8
	Main			82.8± 1.7	286.6± 9.4	78.2± 2.3	274.9± 7.8	71.9± 2.5	257.1± 6.3
TBA	Control	121.0± 3.8		116.7± 4.6		105.1± 2.6$^{\Delta}$		101.2± 4.3$^{\Delta}$	
	Main			73.8± 2.0^{o}		65.1± 4.4^{o}		61.6±3. $^{o\Delta}$	

*Note: * – p < 0.05 reliability relative to the 1st stage of surgical intervention, ** – p < 0.05 reliability relative to the 2nd stage of surgical intervention, Δ – p < 0.05 reliability between the groups of control study areas, o – p < 0.05 reliability between the groups of main study areas.*

Source: compiled by the author

The $PtcO_2$ values in the flaps at the beginning of the operation in the patients of the 1st group where regional anaesthesia was used were 2.3% lower than in the control zone and became 57.8% higher after inhalation with humidified 100% oxygen, indicating a positive local effect of oxygen therapy. In the patients of the second group who underwent intravenous anaesthesia, $PtcO_2$ at the base of the flaps was 36.8% lower than in the control zone at the 2nd stage of the study.

In the skin flap fixation phase and after patients were removed from anaesthesia, Group 1 patients' $PtcO_2$ in the main zone was lower than in the control zone by approximately one-third (32.3% and 35.9%, respectively), and Group 2 patients' $PtcO_2$ difference between the main and control zones was slightly higher – 38.1% and 39.2% in the indicated 3 and 4 phases, respectively.

The difference of PtcO2 between the control values in Group 1 at the main stage of surgery was 5.4%, 9.0% and 9.8% respectively, and in the main zones at the same stage was 10.9%, 16.8%, and 14.4% respectively, which indicates better perfusion in the soft tissues of the operated zone

(skin flaps) in patients operated on under cervical plexus blockade. But the data obtained also show that when reconstructive-plastic surgery is performed using the dermal flap grafting technique after the elimination of post-burn contracture in the neck, oxygen delivery to the surgical manipulation zone worsens with any method of anaesthesia.

Ensuring adequate levels of oxygenation and capnia in the perioperative period is important for patient and flap survival – hypoxia causes catecholamine release and vasoconstriction. Hypocapnia in turn leads to vasoconstriction through local vasoconstriction. This can lead to acidosis and decreased erythrocyte resistance, as well as catecholamine release and subsequent vasoconstriction, which closes the "vicious circle". Therefore, this requires immediate induction of vasodilation to avoid the risk of blood outflow from the flap and to ensure adequate perfusion of the flap.

The degree of perfusion disturbances still depends on the anaesthesia method used. Following the data obtained, Cervical plexus blockade allowed for maintaining more satisfactory $PtcO_2$ values at the base of the transplanted flaps compared to TVA with ketamine and fentanyl. This result may be attributed to the fact that regional anaesthesia provides quality analgesia and regional sympathetic blockade, which leads to vasodilatation with improved flap perfusion.

The findings had an impact on postoperative reconstructive-plastic surgery results as well, which is reflected in Table 3 in the percentage of flap-related complications.

Table 3. Complications associated with the flap

Groups	**Complication rate (%)**			
	Flap necrosis	Wound infection	Wound infection	Graft lysis
Cervical plexus blockades	1.6	–	4.1	–
TBA	4.9	2.1	4.5	1.1

Source: compiled by the author

The presented data indicate a lower percentage of complications when performing reconstructive-plastic surgery on the neck under the conditions of cervical plexus blockade, which is associated with a better blood supply in the flaps after regional anaesthesia. It is worth noting the most frequent occurrence of flap necrosis during intravenous anaesthesia, which indicates a decreased level of perfusion and tropism of the graft. But at the same time, the incidence rates of sublobar hematoma in the first and second groups were almost the same, which indicates the complexity of anastomosis and the influence of anticoagulants intake, which should be considered when selecting doses of drugs before and after surgery.

The temperature measurement monitoring and its values during the stages of reconstructive-plastic surgery are shown in Table 4 below. Such monitoring is of practical importance because hypothermia can harm the flap by causing sympathetic vasoconstriction with reduced perfusion of the flap, resulting in coagulopathy, reduced tropism, and an increased risk of wound infection. Large areas of tissue are exposed to prolonged low temperatures during surgery with a free flap, resulting in hypothermia by evaporation.

Table 4. Changes in temperature and temperature gradient parameters depending on the method of anaesthesia and the stage of surgical intervention (M±m)

Groups		**Research stages**			
		1	2	3	4

Cervical plexus blockades	T_1C (centre)	36.8±0.2	36.7±0.3	36.2±0.2	36.1±0.2
	T_2C (peripheral)	29.7±0.3	28.9±0.3	28.6±0.3*	28.4±0.3*
	T_3C (flap)	28.4±0.4	27.4±0.2*	$28.1±0.3^{\Delta}$	$27.4±0.3*^{\Delta}$
	$\Delta T_1C - T_3C$	8.4±0.3	3.3±0.2*	$8.1±0.2*^{\Delta}$	$6.7±0.3*^{\Delta}$
	$\Delta T_2C - T_3C$	1.3±0.2	1.5±0.2	$0.5±0.1*^{\Delta}$	$1.0±0.2^{\Delta}$
TBA	T_1C (centre)	36.9±0.2	36.5±0.3	36.3±0.3	36.2±0.4
	T_2C (peripheral)	29.4±0.3	28.8±0.2	28.9±0.4	$28.4±0.4^{o}$
	T_3C (flap)	27.9±0.3	26.7±0.2*	$27.1±0.3^{o}$	25.7±0.3*
	$\Delta T_1C - T_3C$	9.0±0.2	$9.8±0.2^{o}$	$8.2±0.3^{\Delta}$	$10.5±0.3^{o}$
	$\Delta T_2C - T_3C$	1.5±0.2	2.1±0.2*	$1.8±0.1^{o}$	$2.7±0.3^{o}*$

*Note: * – $p < 0.05$ relative to the 1st stage of the study, Δ – $p < 0.05$ relative to each stage, o – $p < 0.05$ relative to the corresponding indicators in the groups.*

Source: compiled by the author

From the presented data it is worth noting that the central temperature (in the oral cavity) had some tendency to decrease from the beginning to the end of the surgical intervention, but it kept its values within the limits of the physiological norm. The same tendency was noted for T_2C parameters in the groups reflecting peripheral body temperature.

At the preoperative stage, the temperature indices of the studied area (T_3C) did not differ significantly from the temperature in the healthy areas of the body, which allows us to exclude the influence of external factors on tissue perfusion. The difference between peripheral temperature and flap temperature in both groups was within 1.3-1.5^{o} ($p>0.05$).

As for the dynamics of the flap temperature (T_3C), it was different at different stages of the operation in the studied groups depending on the anaesthesiologic tactics. Thus, in Group 1, where regional anaesthesia was used, at the beginning of the operation, the average flap temperature was 27.4^{o}, at the stage of skin flap fixation it was 3.5^{o} (13.1%) lower than the central temperature, but by the end of the operation, it remained 1^{o} below the peripheral temperatures.

Changes in the parameters of the skin flap temperature in the 2nd group of patients were more pronounced: at the beginning of the operation the average temperature of the flap was 26.7°C, and at the stage of flap fixation it was 8.5°C lower than the central temperature. The lowest values were observed at the end of the operation – 25.7^{o}, which was 1.7^{o} lower than the flap temperature under the regional anaesthesia.

It is worth noting that immediately after regional anaesthesia in group 1 patients the temperature of the operated area increased by almost 1^{o} from the previous values. Comparing the temperature gradient $T_2C - T_3C$ at different stages in the groups, the difference becomes evident already from stage 2: at stages 2, 3 and 4 of reconstructive-plastic surgery, this gradient was 0.6^{o} (2.6%), 3.0^{o} (7.2%), 1.7^{o} (6.6%) respectively. These results presumably indicate a better microcirculation during regional anaesthesia than during total intravenous anaesthesia.

The findings may be related to the fact that performing general anaesthesia redistributes the internal temperature to the peripheral tissues, resulting in a loss of central temperature and ineffective heat release to the colder external environment. It is important to pre-warm patients before surgery to minimize the redistribution of blood flow. In addition, higher ambient temperatures in the operating room, air-supplied warming devices, body heaters, and heated intravenous infusion medications can help avoid hypothermia.

The results of thermometry did not contradict the readings obtained during blood oxygen tension measurements, but only confirmed the assessment of the skin flap condition.

One of the main goals of intraoperative treatment is to minimize secondary ischemia due to vasospasm, intravascular thrombosis and venous stasis due to hematoma or interstitial oedema. The

measurement results indicate the priority of regional anaesthesia over general anaesthesia, because it preserved a more optimal temperature regime and degree of tissue oxygenation at all stages of the operation, which indicates more adequate perfusion of the flap, which reduces the degree of postoperative complications.

The advantages of regional anaesthesia may also include greater safety and economic benefit of the surgery, absence of complications associated with general anaesthesia, which allows effective flap transplantation in elderly patients and patients with comorbid conditions, even if they cannot tolerate general anaesthesia, and good postoperative anaesthesia. A combination of general and regional anaesthesia may be explored in the future.

It can also be argued that assessment of the temperature gradient and oxygen tension by percutaneous contact polarography in the soft tissues of the operated area is an informative indicator as a criterion of anaesthesia adequacy in the elimination of facial, neck and thoracic contractures. These methods can serve as a good complement to regular flap monitoring using clinical observations (which is the "gold standard"). Other auxiliary techniques such as Doppler, microdialysis, fluorescence angiography, or near-infrared spectroscopy are also useful in the perioperative period to further explore and optimize anaesthetic tactics.

4. Discussion

A retrospective study by E.M. Busby et al. [16] evaluated regional anaesthesia in the aspect of perioperative analgesia in reconstructive surgeries on the neck and head. They point out that the clinic relies heavily on narcotic analgesics to treat moderate to severe postoperative pain. This has negative consequences because there is evidence of the deleterious effects of such analgesics as well as their potential for long-term abuse. Therefore, the benefits of regional anaesthesia are worth considering for effective pain management while limiting the use of narcotic analgesics. Regional catheter anaesthesia can be performed postoperatively for several days, resulting in less overall use of narcotic analgesics and fewer related side effects, being less invasive.

A. Smith et al. [17] performed a systematic review of the existing literature on the effectiveness and advantages of regional anaesthesia in comparison with other methods of flap reconstructive plasty. They did not come to a definite conclusion, because on the one hand, it is argued that blockade of sympathetic innervation pro anaesthesia leads to hemodynamic changes and negative visceral afferent impulsion, which causes catecholamine release and vasoconstriction, and this can affect flap perfusion and increase risks of postoperative complications. The authors also note the analgesic effect of regional anaesthesia, which can affect the results of flap plasty, since inadequate relief of surgical pain can reduce the oxygen tension in the tissues by as much as 25 mm Hg, which again leads to the problem of hypoperfusion. At the same time by the example of epidural anaesthesia it was shown that its hemodynamic effects increase tissue oxygenation in an anesthetized areas-an increase of subcutaneous partial oxygen pressure by 9 ± 2 mm Hg in femoral arteries was recorded. Improvement of microcirculation in the tissue flaps, reduction of venous stasis and prevention of vasospasm when using epidural anaesthesia was also observed.

It has been previously mentioned that regional anaesthesia leads to vasodilation. The authors draw attention to the "rip-off phenomenon" in which blood is redistributed from the flap tissue to the native tissue, especially on the background of hypotension – this condition can develop with a combination of regional and general anaesthesia, as the latter can lead to hypotension and bradycardia, and vasodilation is rapidly replaced by vasoconstriction. Current practice includes prevention of vasoconstriction by using inhaled drugs (e.g., sevoflurane or isoflurane), adequate fluid administration, body temperature control, and maintaining haemoglobin levels of at least 70-110 g/l [18]. But it is worth noting that the use of inhaled anaesthetics may be limited in patients with facial and neck contractures, which complicates access to the patient's airways.

In 2021, S. Galitzine et al. [19] from Oxford University Hospitals published a series of clinical cases where they described the strategy of regional anaesthesia without sedation in patients who underwent tissue excision for lower limb osteomyelitis with flap plasty of the defect. This study is interesting due to the evaluation of the subjective sensations of the patients in the perioperative period. The operative time range was 240-875 min. In the postoperative period 50 patients filled out a standard questionnaire about their experience before surgery, in the anaesthesia room and operating room: 80% were aware of the procedure at least "some time"; 72.5% of patients and 75% respectively had no anxiety in the anaesthesia room and operating room; 97.5% of patients who recalled their surgery reported that in general, their sensations were "comfortable" or "very comfortable". It is worth emphasizing that in this subgroup, 91.3% reported that recovery after regional anaesthesia was "faster" than after general anaesthesia. In addition to the classical anaesthetic tactics, audiovisual distraction was applied to the patients, which ensured psychological comfort during the surgery.

As stated earlier, it is often impossible to intubate patients with post-burn facial and neck contractures. H. Y. Embu et al. [20] from Jos University Teaching Hospital published a study on the anaesthetic management of patients with mentosternal contractures with organic resources. The authors report their experience that this problem can be overcome with the use of ketamine, inhalation anaesthesia, and the use of a laryngeal mask before the contracture is removed. Cases of 15 patients (12 males and 3 females) between the ages of 6 and 65 years were described. Five patients were administered ketamine and maintained with the same drug. In five other cases, anaesthesia was performed using inhalation drugs through a face mask after induction with ketamine. A laryngeal mask was placed in six cases, and in one patient a tracheostomy under local anaesthesia was necessary. The authors state the absence of perioperative complications and insist on the advantages of combined anaesthetic tactics.

Regarding the intraoperative assessment of flap perfusion during reconstructive surgery, many techniques allow doing this, one of which is the transcutaneous determination of oxygen tension in the blood.

B.S.Leenstra et al. [21] conducted a study in which 10 patients who underwent lower limb revascularization were included, and $PtcO_2$ values of the affected lower limb were measured preoperatively, during and after revascularization. The results were compared with the preoperative and postoperative ankle-brachial index and with perioperative angiography. In the end, 2 of 12 measurements were unsuccessful; 8 of 10 patients showed significant clinical improvement and an increase in $PtcO_2$. The 2 patients who did not improve clinically had no change in intraoperative angiography and no increase in the ankle-brachial index or $PtcO_2$. Thus, the researchers concluded that photo-optical transcutaneous oxygen tension measurement can serve as an intraoperative tool for assessing the success of revascularization, both as an alternative to the existing methods and as an element of comprehensive monitoring.

At the same time, T.E. Serena et al. [22] analysed 24 cases among 10 patients using transcutaneous oxygen tension measurement and infrared spectrometry in comparison to monitoring difficult-to-heal wounds. After a comparative analysis of the data obtained, it was shown that the oxygen measurement score using transcutaneous oxygen tension measurement was overestimated compared to the second technique. The authors recommend further study in a larger population but preliminarily state that infrared spectrometry offers more advantages as specialists get immediate visualization of tissue oxygenation at the point of care using a portable device, the procedure itself is simpler, and this method allows to measure oxygenation in the wound bed while transcutaneous oxygen tension measurement does not.

Data on the temperature gradient measured by electrical thermometry have been virtually nonexistent in recent years. But it is worth paying attention to the study conducted by M.J. Rabbani

et al. [23]. The study evaluated both vascular stalk flaps and free flaps in the ratio of 68 cases (81%) and 16 cases (19%), respectively. Flap perfusion was assessed using a temperature gradient in the colour-coded thermal image, compared with clinical assessment, which included colour, temperature, and capillary filling. As a result, the diagnostic accuracy of the thermal imaging camera was 96.43% with a sensitivity of 98.7%, and a specificity of 75%. Thus, this technique is an effective and useful adjunct to clinical assessment as it is a simple and non-contact monitoring method.

Shokriand J.G. Lighthall [24] reached similar conclusions. They studied the method of infrared thermography to determine the contours of angiosomes and monitor adequate tissue perfusion in pre-, intra-, and postoperative conditions. This technology was compared with conventional fluorescence angiography, and they state that infrared thermography is simpler, more informative and, importantly, non-contact.

Thus, combined monitoring of $PtcO_2$ and flap temperature can provide valuable prognostic data to assess perfusion and the risk of postoperative complications. Contradictory data were found regarding transcutaneous oximetry, but this study only supports the hypothesis about the advantages of this method. International experience of anaesthetic tactics in reconstructive flap surgery suggests the effectiveness of regional anaesthesia, which reduces the percentage of postoperative complications due to vasodilation and improved flap perfusion – these data correlate with the results of this study as well.

5. Conclusions

Facial and neck burns are a common problem in both adults and children, and post-burn contractures of this localization leave a cosmetic and anatomical defect of the skin and airways of patients, which makes it impossible to perform inhalation anaesthesia by intubation, and even through a face mask. At the pathophysiological level, this also leads to a decrease in tissue tropism (hypoperfusion) and the development of complications in the postoperative period when flap plasty is attempted.

The degree of perfusion disorders depended on the method of anaesthesia used. Following the data obtained, regional anaesthesia maintained more satisfactory $PtcO_2$ values at the base of the transplanted flaps than total intravenous anaesthesia with ketamine and fentanyl. Such results may be attributed to the fact that local nerve blockade provides qualitative analgesia, vasodilation, and a decrease in catecholamine levels, which leads to improved flap perfusion. It becomes possible to state that assessment of the temperature gradient and oxygen tension by percutaneous contact polarography in the soft tissues of the operated area are qualitative predictors of the adequacy of anaesthesia in the elimination of facial, neck and thoracic contractures. These methods can serve as a good complement to regular flap monitoring using clinical observations as well as other techniques such as infrared thermometry, Doppler angiography, spectrometry, and others, which require further research on their combination and comparison.

Contradictory data on transcutaneous oximetry were found in the studies of other specialists, but the results support the hypothesis about the advantages of this method. International experience on the effectiveness of regional anaesthesia is still not large enough and has not been introduced into daily practice, but this technique has several advantages: greater safety and economic benefit of surgery, the absence of complications associated with general anaesthesia, which allows effective flap transplantation in older patients and patients with comorbid conditions, good postoperative analgesia and reduced need for narcotic analgesics. A combination of general and regional anaesthesia may be explored in the future.

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