Treatment Of Fractures of The Leg Bones and Polarographic Control of Blood Supply to Tissues

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ABSTRACT

Using the method of polarography with open needle sensors and transcutaneous polarography, various groups of patients with fractures of the lower leg bones were examined during the treatment. It was found that with closed helical fractures, as the severity of the injury increases, the rate of capillary blood flow and oxygen utilization in the tissues decreases. With closed helical fractures with displacement of fragments up to 75% of the diameter of the bones increase, and with large displacements, as well as with comminuted and open fractures, muscle elasticity, volumetric blood flow velocity of the leg and oxygen tension in the tissues decrease.

Keywords: blood supply to the lower leg, treatment of fractures, tissue oxygenation.

Introduction

The use of various methods for studying microcirculation in the treatment of patients with fractures of extremity bones using the Ilizarov method gives an ambiguous answer to the question about the state of blood supply to tissues. While tissue temperature and volumetric blood flow velocity of the injured limb increase [3], the rheographic index, reflecting fluctuations in the electrical resistance of tissues, indicates a significant decrease in the pulse blood filling of the arteries [2]. V.E. Udaltsov identified 4 types of oxygen regime in tissues: when the indicators do not differ from those of healthy people, hyperoxic, hypoxic and critical hypoxia regime [1].

To quantify, using the polarography method, the influence of various factors on the oxygen regime in the tissues of the extremities, it is important to have a standardized treatment method and various options for research techniques (using open platinum electrodes for intradermal and transcutaneous determination of oxygen tension).

Materials And Methods

The purpose of the study is to determine the oxygen regime in tissues in various fractures of the leg bones in the conditions of treating patients using the method of transosseous compression osteosynthesis.

The method of polarographic determination of oxygen tension is based on assessing the displacement of the electrode potential when the ion concentration changes in the electrochemical “electrode-tissue” system. We used a polarographic analyzer RA-2 with open platinum indicator electrodes in the form of a needle with a diameter of 0.2 mm, which, after calibration, were inserted into the subcutaneous tissue of the foot. The correct interpretation of changes in the level of partial oxygen tension (pO2) in tissues is of great importance.

Results And Discussion

A decrease in pO2 can occur both due to a decrease in its delivery through the vessels and increased consumption in tissues. Therefore,

an additional oxygen test is carried out with a minute inhalation of pure oxygen, an ischemic test with occlusion of the afferent arteries until a marbled skin pattern appears and the time of depletion of the oxygen supply is determined (seconds). In addition, a test is carried out with inhalation of hydrogen from a bag of gas and subsequent determination of the rate of leaching of hydrogen from tissues (a redoximetric method for assessing tissue blood flow). Additionally, the volumetric blood flow velocity of the lower leg was determined using the Whitney occlusion plethysmography method and the tone of the gastrocnemius muscle using the myotonometry method.

We examined 25 patients aged 15 to 60 years with closed helical fractures of the tibia under treatment using the Ilizarov method. The severity of the damage was assessed by the magnitude of the displacement of the tibia fragments across the width. When presenting for a follow-up examination, the studies were repeated at various times (up to a year or more than a year) after the end of treatment.

In patients with closed helical fractures, the influence of the degree of displacement of tibial fragments in width relative to each other during trauma on the speed of tissue blood flow was analyzed. It turned out that with an increase in the displacement of fragments to 33-50% of the width of the tibial diaphysis, the speed of tissue blood flow in the lower leg decreased.

This conclusion about the unfavorable effect of increasing the severity of injury on the oxygen regime in tissues is confirmed by analyzing the time of depletion of the oxygen supply in tissues during an ischemic test. The slowdown of metabolic processes in tissues with increasing severity of damage leads to the fact that with significant displacements of fragments in tissues, relatively higher values of oxygen tension and maximum oxygen tension are observed. And only in closed helical fractures with fragments displaced by more than 75% of the diameter of the diaphysis is a decrease in oxygen tension observed.

It is also interesting that the elasticity index of the gastrocnemius muscle was also highest in patients in whom the displacement of fragments during injury reached 50% of the diameter of the tibial diaphysis. As the severity of the injury increased, the indicator decreased (Table 1).

Table 1

Some indicators during the treatment of patients and after its completion (M±m)

Type of fracture and treatment time	n	Calf muscle tone (conventional units)	Volumetric blood flow velocity (ml/min*100 cm^3)	Tissue blood flow (ml/min*100 cm^3)	Oxygen depletion time (s)
Helical	18	**190**±17	**3,47**±0,42	**24,1**±2,5	**206**±18
Splintered	6	**144**±20	**1,73**±0,58	**17,9**±1,1	**269**±58
Upcoming dates	8	**122**±19	**1,55**±0,31	**24,1**±2,9	**306**±43
Distant terms	11	**101**±15	**1,44**±0,25	**21,7**±2,5	**420**±51

An increase in oxygen tension in tissues with significant displacements of fragments was also facilitated by an increase in the volumetric velocity of blood flow. This indicator largely depends on local reflex and biomechanical regulatory mechanisms. In particular, increasing the elasticity of skeletal muscles helps to reduce transmural pressure in the walls of arteries and increase the volumetric velocity of blood flow. Consequently, the direction of changes in the general and capillary blood flow of the injured limb are different: with an increase in the degree of injury, the capillary blood flow becomes smaller, and the increase in total blood flow to a known limit of displacement of fragments is carried out due to an increase in the speed of the shunt blood flow.

When conducting studies of the gas regime of tissues using the transcutaneous polarography method, we found the same values of oxygen tension in tissues as with polarography with needle sensors. In the control group of healthy subjects, the values of

transcutaneous oxygen and carbon dioxide tension tended to decrease with increasing age, which may be associated with both a decrease in the rate of tissue blood flow and the rate of oxygen utilization in tissues.

We have not identified significant differences in oxygen tension in the skin of the thigh, leg and foot (66±3.0, 64±1.7 and 62±0.4 mm Hg, respectively) and carbon dioxide (respectively 28±2.5, 35±2.3 and 34±1.6 mmHg). The nature of the fracture had a more significant effect on the level of gas tension in the tissues.

The difference between the oxygen and carbon dioxide tension values was normally 25 mmHg. Art., in patients with closed helical fractures of the leg bones - 40 mm Hg. Art., with comminuted fractures - 47 mm Hg. Art. and in patients with open fractures - 51 mm Hg. Art. An increase in the oxygen tension gradient in severe injuries of the leg bones indicates both a slowdown in oxygen delivery and insufficient utilization of it by tissues.

In patients with closed comminuted fractures of the leg bones, the muscle tone index was relatively lower, the volumetric blood flow rate of the leg and tissue blood flow were lower, and the rate of oxygen utilization was higher than in helical fractures. After the end of treatment of the patients, muscle tone and blood flow speed gradually normalized, and the rate of oxygen utilization slowed down.

Conclusion

Consequently, in the treatment of closed helical fractures of the leg bones, as the degree of displacement of fragments increases, a slowdown in the rate of capillary blood flow and oxygen utilization in the tissues is revealed. The observed increase in muscle tone, volumetric blood flow velocity and oxygen tension in tissues in patients with displacement of fragments by more than 75%, as well as in patients with comminuted and open fractures, is replaced by a tendency towards a decrease in the corresponding indicators.

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