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Emergency Laser Photodestruction of Benign Vascular Formations of the Skin in Children, Complicated by Bleeding

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BACKGROUND Benign vascular lesions of the skin, hemangiomas and pyogenic granulomas are quite common in pediatric patients, which are complicated with bleeding in 7.5% of cases.

MATERIAL AND METHODS In 2016–2018, 17 children with cavernous hemangiomas and pyogenic granulomas complicated with bleeding were operated on an emergency basis at the Research Institute of Emergency Children's Surgery and Traumatology. Surgical intervention for all patients was performed using the method of interstitial selective laser photodestruction developed by the RIECST, which took out the utility patent. This method was implemented using two wave laser surgical device IPG "IRE-Polus" (Russia), generating two wavelengths of laser radiation of 0.97 μm and 1.56 μm.

RESULTS The analysis of the long-term results of treatment in 17 pediatric patients who were operated on an emergency basis for hemangioma and pyogenic granuloma complicated by bleeding showed that all 17 patients (100%) had a good clinical and aesthetic result. The method of interstitial selective laser photodestruction provided a radical removal with guaranteed hemostasis of the indicated benign vascular lesions of the skin complicated with bleeding illustrate the effectiveness of this method in clinical practice, as well as the possibility of its use in inpatient and outpatient conditions.

CONCLUSION To prevent the large blood loss in hemangiomas complicated by bleeding and pyogenic granulomas of the skin in children, emergency surgical treatment has been performed using interstitial selective laser photodestruction. This method ensures the radical photodestruction of tissues of a pathological vascular formation and reliable hemostasis, which guarantees the achievement of a good clinical and aesthetic result of treatment in inpatient and outpatient conditions in all cases.

Keywords: benign vascular lesions of the skin, hemangioma, pyogenic granuloma, hemorrhage, urgent laser photodestruction, pediatric patients

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CFI – color flow imaging

INTRODUCTION

Vascular tumors such as hemangiomas and inflammatory forms of teleangiodisplasia, pyogenic granulomas are benign vascular lesions of the skin, which are often found in children.

Hemangioma is a congenital vascular tumor of the skin, detected with a frequency of 2% in newborns and up to 10% in children under one year, occurring 3 times more often in girls than in boys [1-10]. Most often, hemangiomas are located on skin and subcutaneous tissue on the head, face, neck, and upper trunk [8–15]. Various complications in hemangiomas are noted in 40% of cases, of which bleeding is 7.5% [16]. Complicated bleeding occurs when there are rapidly progressive forms of hemangioma protruding above the skin and an increasing part of the vascular formation with ulceration and infection of the surface [9, 16–19].

Pyogenic granuloma is an acquired benign vascular formation, an inflammatory form of telangiodysplasia, resulting from a reactive change of the vessel with the formation of inflammation, often at the site of previous damage to the skin [20]. The pyogenic granuloma consists of the cutaneous part, in the form of a red-brown color of a relatively small spherical element, and an intradermal expanded vessel located almost vertically below it [20].

Pyogenic granuloma is located more often on the face and upper parts of the body, but can also be located on another part of the body, for example, on the extremities [8, 10, 20, 21]. The characteristic of a pyogenic granuloma is its rapid growth, further erosion, ulceration of the surface and, relatively heavy bleeding in minimal trauma, due to the presence of an intradermal, pathologically dilated vessel [8, 10, 20, 21].

Complications such as bleeding from the injured tissues of pyogenic granuloma are noted in 7.5% of cases [16].

A predisposing factor for the occurrence of complications followed by bleeding in all the pathological vascular lesions considered is the presence of a percutaneous protruding part with thin, often altered skin, easily subject to mechanical or other damage [21, 22]. Complications with bleeding, especially in small children, are dangerous by the rapid development of hemorrhagic shock due to a decrease in circulating blood volume, macro- and microcirculatory hemodynamic disorders [9, 10, 15].

All experts consider the presence of bleeding from the tissues of the above vascular formations to be an absolute indication for emergency surgical treatment due to the difficulty of its management with non-surgical methods [20, 21].

However, today, none of the surgical removal methods for vascular formations complicated by bleeding does not allow achieving a radical result of treatment with good clinical and aesthetic effect [20, 23–25].

Currently, one of the effective, accurate and radical methods of surgical treatment of various forms of vascular lesions of the skin and subcutaneous tissue is laser photodestruction in the range of wavelengths selective for hemoglobin and water, which predominate in the indicated vascular structures compared to the surrounding tissues [26–30]. The light absorption spectra of the skin chromophores are shown in Fig. 1 [30–35].

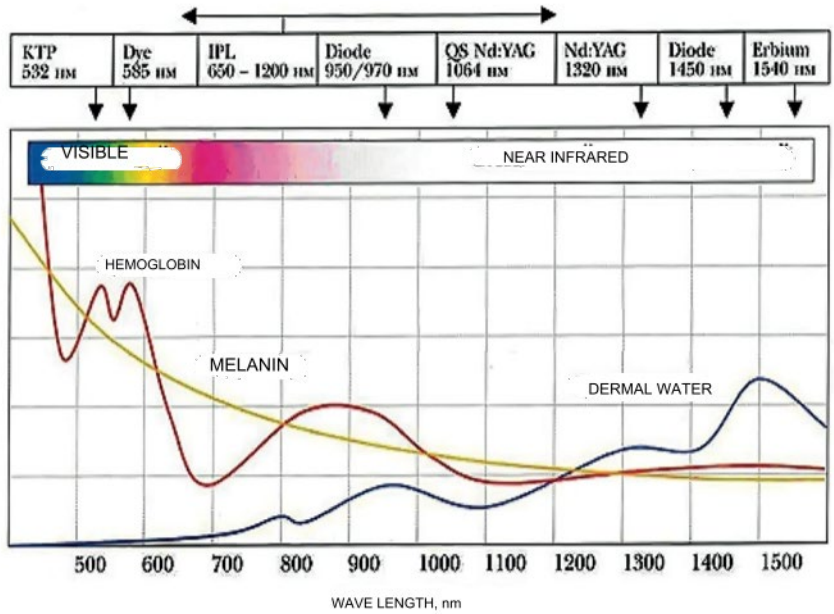


Fig. 1. Light absorption spectra of skin chromophores. The horizontal axis — wavelengths (nm); on the vertical axis — absorption coefficient of radiation by hemoglobin, melanin, water

Based on the phenomenon of selective absorption mainly by hemoglobin and water of laser radiation with a wavelength of 0.97 μm and 1.56 μm, respectively, and taking into account the clinical needs, the Research Development Institute of Emergency Children Surgery and Trauma method developed interstitial selective laser photodecomposition of cavernous hemangiomas in children and received a patent for invention [28-30]. The method is provided with an optimal combination of the modes of the specified selective laser radiation and its delivery directly to the tissue of the vascular formation. This allows us to predict the volume and severity of photodegradation of pathological tissues of formation without damage to the surrounding tissue structures, which creates optimal conditions for improving local regenerative processes.

The developed method was first used at RIECST not only for the planned surgical treatment of cavernous hemangiomas and pyogenic granulomas, but also in cases of bleeding complications requiring emergency treatment [28, 29].

The purpose of this work was to achieve good clinical and aesthetic results of treating children with hemangiomas and pyogenic granulomas complicated by bleeding using emergency laser methods of removal.

MATERIALS AND METHODS

We analyzed clinical observations of the results of treatment at RIECST of pediatric patients operated on an emergency basis using the method of interstitial selective laser photodestruction for bleeding of hemangiomas and pyogenic granulomas. The article reports clinical examples.

In 2016-2018, 17 children were operated on an emergency basis for hemangiomas and pyogenic granulomas of the skin and subcutaneous tissue, complicated with bleeding.

There were 9 children with hemangiomas complicated by bleeding, 5 of them with a simple cavernous form and 4 with a combined cavernous form. Pyogenic granuloma with bleeding was diagnosed in 8 patients. Characteristics of

17 patients are presented in Table 1.

Table 1

The characteristics of patients with vascular lesion complicated with bleeding

Diagnosis	Number of patients	Age groups, years	Gender distribution	Surgery within 12 hours	Surgery within 12-24 hours
Cavernous hemangioma	9	3 months–1.5	6 girls; 3 boys	9	0
Pyogenous granuloma	8	3–12	4 girls; 4 boys	2	6
Total	17	3 months–12	10 girls; 7 boys	11	6

There were twice less female children with bleeding hemangioma, and there was equal number of boys and girls with complicated pyogenic granuloma. Patients with hemangiomas had an earlier age — from 3 months to 1.5 years; with pyogenic granuloma, the children were older — from 3 to 12 years.

In structure, all benign vascular lesions of the skin had a protruding cutaneous part with damaged skin and were located in places prone to traumatic injuries: face, folds of the neck, less often in the upper torso and extremities.

Based on the history of all patients, the traumatic cause of bleeding from the vascular formation was ascertained: damage with clothes, toys, skin maceration others. After an unsuccessful attempt to control bleeding parents sought specialized medical assistance at RIECST.

Before the operation, all patients with active bleeding from the vascular formation were treated with local conservative hemostatic treatment. The hemostatic sponge was used in six patients with cavernous hemangioma, the compression bandage with a solution of hydrogen peroxide was put in remaining 11 patients. The general condition of all patients in the preoperative period was satisfactory, and they did not need additional preoperative preparation. All patients underwent a clinical blood test with the determination of clotting time and bleeding duration, and also blood group and rhesus factor. The state of the vascular formation before the operation was fixed photographically. Diagnostic ultrasound of the examined vascular formations allowed to determine the type and rate of blood flow in the abnormal vascular tissue, as well as in observations with cavernous hemangioma in 2 patients to detect the presence of relatively large regional vessels that require ligation during surgery, and in patients with pyogenic granuloma to determine the size its basal vessel for precision interstitial photolysis.

Surgical treatment of all these patients was performed using a two-wave laser surgical apparatus IPG IRE-Polus (Russia) with a radiation wavelength of 0.97 μm and 1.56 μm and a maximum power of 15 W and 5 W, respectively. The method of interstitial selective laser photodestruction by this device was used [28].

In terms of not more than 12 hours after treatment, 9 patients with non-recovering bleeding from hemangiomas underwent emergency surgery in an operating hospital with general inhale mask, laryngeal mask anesthesia with sevoflurane. The use of general anesthesia was determined by age (if the patient was under 1.5 years old), as well as by the feature of the photodestruction mechanism, whose effectiveness is reduced if the tissues are excessively filled with fluid. In this case, 2% Novocaine solution was administered (0.3–0.5 ml).

Two patients with severe bleeding from pyogenic granuloma were also operated on an emergency basis.

Emergency delayed surgery for bleeding pyogenic granuloma was performed in 6 patients from 12 to 24 hours after treatment. All patients with pyogenic granuloma were operated on under ambulatory operating conditions and local anesthesia: in 4 of them only application anesthesia with anesthetic ointment EMLA was applied, and in the other 4 cases, due to the presence of a relatively wide base of the tumor, combined anesthesia was performed: application of EMLA ointment in combination with 2% injections solution of novocaine in the surrounding tissue.

The duration of the operation using the method of interstitial selective photodestruction was minimal and averaged no more than 3-5 minutes when removing pyogenic granulomas, and from 5 to 10 minutes for hemangiomas, regardless of their size.

RESULTS

During the operation, effective photodestruction of vascular formation tissue and complete hemostasis were noted, there were no complications. During the entire postoperative period, the condition of all patients was satisfactory, the children were calm, the area of operation did not bother them, there was no hyperthermia. In case case of surgical treatment at the hospital, the children stayed there on average no more than 3-5 days, then they were discharged for outpatient treatment.

In all cases, the postoperative wound process corresponded to physiological terms, but the local aseptic nature of wound inflammation, typical of laser wounds, was without the involvement of the tissues surrounding the postoperative wound. On day 21–30, the postoperative wound defect was completely closed by the epithelium and made a flat, non-deforming skin with a postoperative scar, having a much smaller area compared to the previously existing vascular formation.

All patients in the long-term period after surgery from 1 year to 2.5 years were given control examinations at least once every 3–6 months, with mandatory photographing of the area of operation, as well as performing a control ultrasound.

In all cases, it was found that there was no recurrence and residual elements of the vascular formation, the photodestruction zones were represented by slightly lighter, even and not distorting the skin in small areas.

Based on the analysis of the follow-up data, all 17 patients showed a good clinical outcome of treatment without residual elements of the vascular formation, confirmed by ultrasound data, with the optimally possible favorable aesthetic component.

Clinical examples

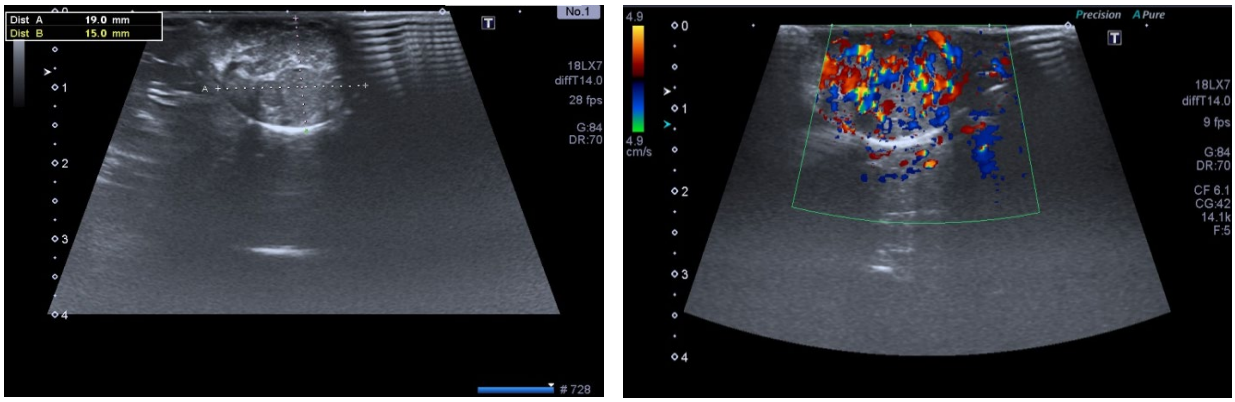
Clinical observation 1. Patient K., 1 year 6 months.

Diagnosis: "Combined cavernous hemangioma of the lower lip, complicated by bleeding."

Since birth, the child has been monitored for a combination of cavernous hemangioma of the lower lip at the surgeon's place of residence. At the age of 1.5 years, when getting a child dressed, parents noticed bleeding from a wound on the surface of the hemangioma, and he was taken to RIECST (Fig. 2).

Fig. 2. Combined cavernous hemangioma of the lower lip, complicated by bleeding. A volumetric, convex, intense vascular formation with a wound on the inflamed surface, significantly distorting the lower lip. Before surgery, conservative methods were used to stop bleeding from a wound on the surface of the hemangioma temporarily

After a temporary control of bleeding, an ultrasound was performed (Fig. 3 *A, B*). Two hours after admission, interstitial selective laser photodestruction of lower lip hemangioma tissues was performed under the general inhalation laryngeal mask anesthesia with sevoflurane. The operation was performed using a combination of two laser wavelengths, with a wavelength of 0.97 μm and 1.56 μm, power 5.0 W and 2.5 W, respectively, with a total power of 7.5 watts. The view of the operation area during laser photodestruction of hemangioma tissues is shown in Fig. 4.



A **B**

Fig. 3. Ultrasound examination of vascular formation of the lower lip before surgery. A hypoechoic formation of about 28x15 mm in size is determined, the contours are clear, the contents are heterogeneous. A — surrounding tissue without visible changes; B — color Doppler imaging: the blood flow is pronounced, vessels with a diameter of 1 mm are visualized

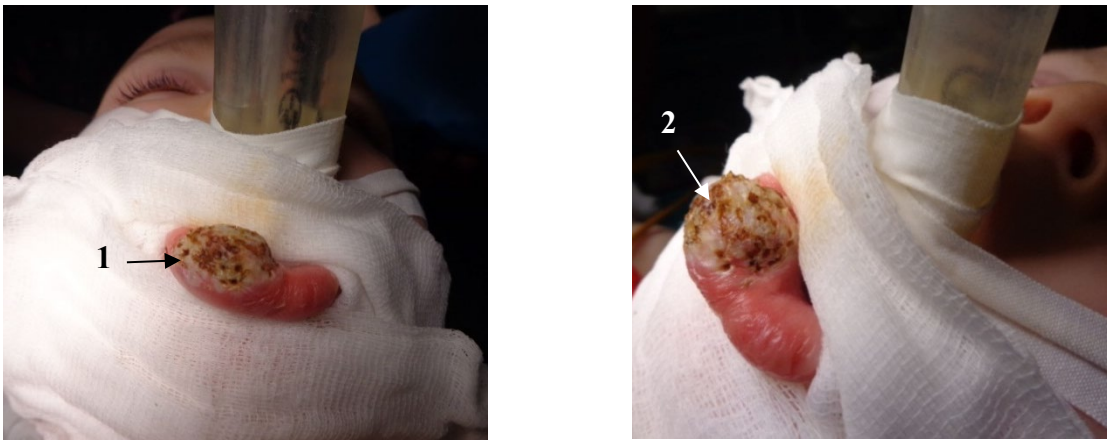


Fig. 4. Coagulated tissue of vascular formation, the result of interstitial selective laser photodestruction. Fully coagulated hemangioma and hemostasis tissues. 1 — coagulation perforations for delivering laser radiation to the hemangioma tissue; 2 — coagulated tissue of hemangioma

The postoperative period was uneventful. The examination 1 year after the surgery revealed good clinical results with a slight defect contour of the lower lip (Fig. 5 *A).* Two years after the operation, a very good clinical and aesthetic result was noted with full restoration of the contour of the lower lip and the absence of elements of vascular formation (Fig. 5 *B*). The good result of treatment was confirmed by control ultrasound data (Fig. 6).

Fig. 5. The result of treatment 1 and 2 years after the surgery. A — 1 year after the operation a good clinical and aesthetic result was noted. There was no malformation on the lower lip, a slight defect in the contour of the lower lip was determined; B — 2 years after the surgery a very good clinical and aesthetic result with full restoration of the contour of the lower lip and the absence of elements of vascular formation was observed

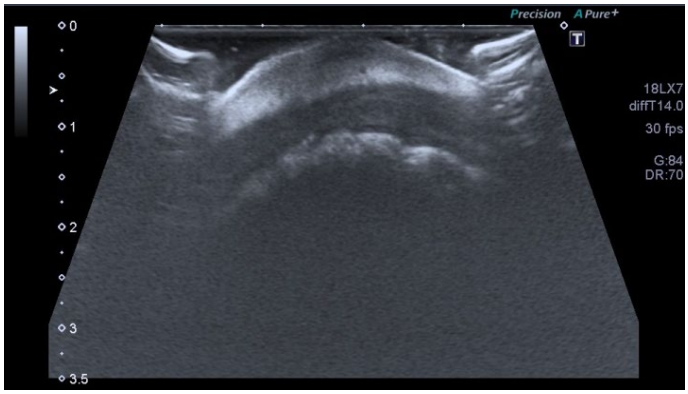


Fig. 6. The control ultrasound 2 years after the surgery. In the area of the photodestruction of the lower lip, a hypoechoic formation of irregular shape 4x3 mm in size (scar) was preserved

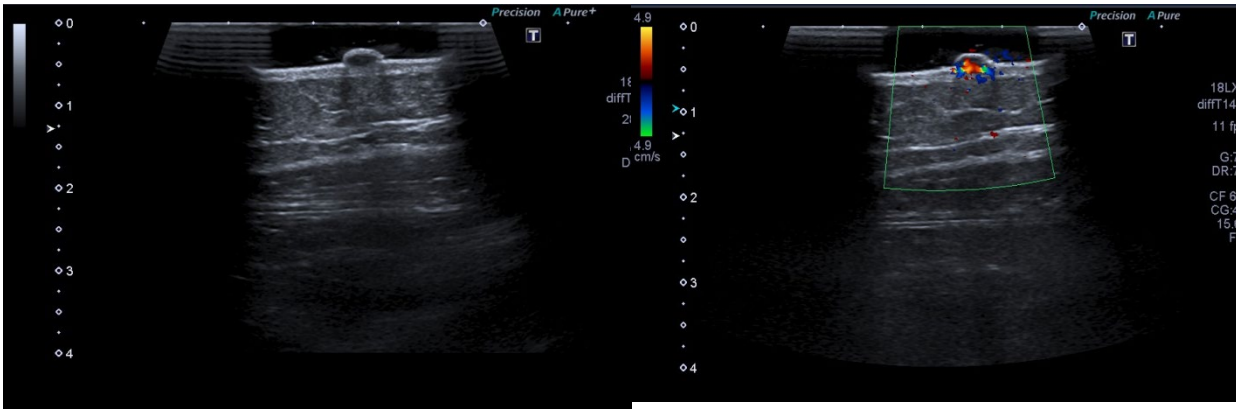
Clinical observation 2. Patient R., 1 year 6 months.

Diagnosis: "Pyogenic granuloma of the right cheek, complicated by bleeding."

At the beginning of October 2016, a small red dot on the right cheek was found in the child, which subsequently increased in size and acquired the form of a convex rounded red formation. A month later, in November 2016 the boy injured the formation with a toy which caused bleeding, parent referred to RIECST. The type of pyogenic granuloma complicated by bleeding is

presented in Fig. 7. An ultrasound of the vascular formation was performed before the operation (Fig. 8). An hour after treatment, on an outpatient basis, under local combined anesthesia: EMLA application ointment combined with an injection of a 2% solution of novocaine (0.5 ml), prompt removal of the pyogenic granuloma of the right cheek was performed (Fig. 9). The operation, interstitial selective laser photodestruction, was performed using a combination of two wavelengths of laser radiation — 0.97 μm and 1.56 μm, with a power of 3.0 W and 2.0 W, respectively, with a total power of 5.0 W. The postoperative period was uneventful. Good clinical and aesthetic results were noted 6 months later (Fig. 10).

Fig. 7. Pyogenic granuloma of the right cheek, complicated by bleeding. The state before the operation. Round, convex, red-colored formation, up to 1.0 cm in diameter, active bleeding from damage at the base of the tumor



A **B**

Fig. 8. Ultrasound examination of vascular formation, pyogenic granuloma of the right cheek, before the operation. A — the hypoechoic formation is determined with dimensions of about 10x12 mm, the contours are clear, the contents are heterogenous. The surrounding tissue without visible changes. B — color Doppler imaging: the blood flow is clearly expressed in the epidermal part, subdermal single vessels are visualized

Fig. 9. The operation area immediately after interstitial laser photodestruction. The postoperative wound is represented by a dry coagulation crust treated with a concentrated solution of potassium permanganate, complete hemostasis

Fig. 10. The result 6 months after the photodestruction of pyogenic granuloma complicated by bleeding. The area of operation is represented by a slightly pinkish small spot, the elements of the vascular formation are not defined, the skin is not deformed. Good clinical and aesthetic result of treatment

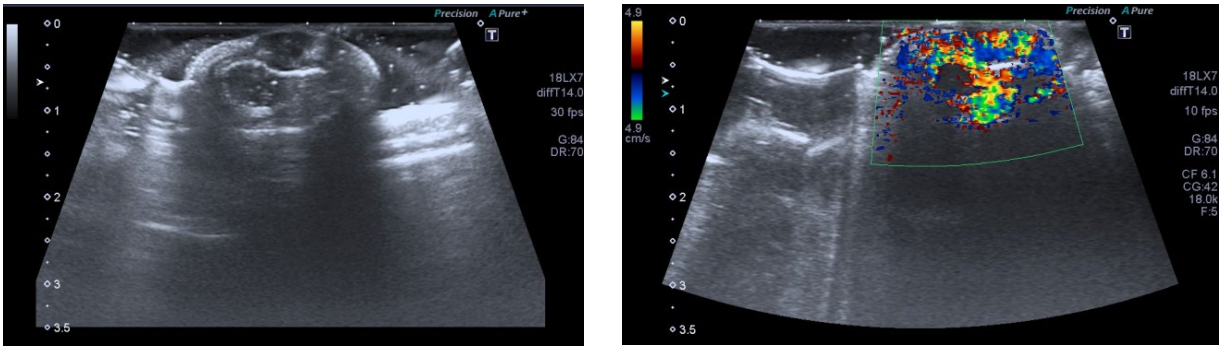
Clinical observation 3. Patient P. , 3 months.

Diagnosis: "Combined cavernous hemangioma of the right auricle, complicated by bleeding."

The surgeon at the place of residence has observed the child since birth due to the combined cavernous hemangioma of the right auricle. Hemangioma gradually increased in size, small wound appeared on its surface, which occasionally bleeded. Parents controlled minor bleeding with conservative methods at home. At the age of 3 months, when getting the child dressed they damaged the hemangioma surface by clothing, there was relatively heavy bleeding. The child was taken to RIECST .

Upon admission, the bleeding from the damaged tissues of the hemangioma surface was controlled conservatively (Fig. 11). Before the operation, an ultrasound of the vascular formation was performed (Fig. 12).

Fig. 11. Combined cavernous hemangioma of the right auricle. The state before the operation after a temporary stop of bleeding by conservative methods. A convex, irregular shape, red color with an uneven surface is determined; the skin is thinned, with minor wound lesions and blood traces



A **B**

Fig. 12. The ultrasound examination of the combined cavernous hemangioma of the right auricle prior to surgical treatment. A — a hypoechoic formation of about 8x3.7 mm in size is determined, the contours are clear, the contents are heterogenous. The surrounding tissue without visible changes. B — color Doppler imaging: the blood flow is pronounced, the rate of blood flow is sharply increased

One hour after admission and preoperative preparation, interstitial selective laser photodestruction of tissues of the combined cavernous hemangioma of the right auricle was performed under the general inhalation laryngeal mask anesthesia with sevoflurane. The operation was performed using a combination of two wavelengths of laser radiation — 0.97 μm and 1.56 μm, with a power of 6.0 W and 3.0 W, respectively, with a total power of 9.0 W.

The view of the operation area immediately after laser photodestruction of hemangioma tissue of the right auricle is presented in Fig. 13.

The immediate postoperative period was uneventful.

When viewed 7 months after surgery, good clinical and aesthetic results were noted with the restoration of the auricle shape and the complete absence of elements of vascular formation (Fig. 14). A good clinical result was confirmed by the control ultrasound data (Fig. 15).

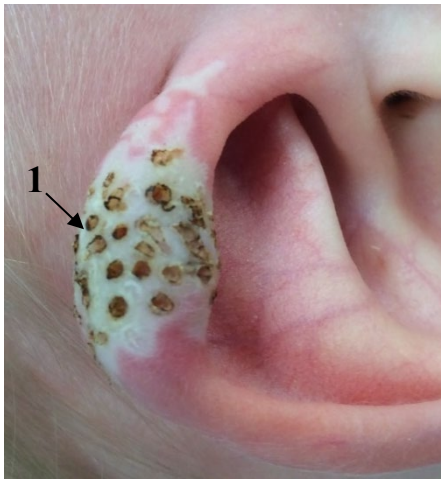


Fig. 13. Coagulated tissue of vascular formation during surgery after laser photodestruction. Fully coagulated hemangioma tissues and complete hemostasis as a result of laser selective interstitial photodestruction are presented. 1 — skin coagulation perforations for delivering laser radiation to the hemangioma tissue

Fig. 14. The result 7 months after the surgery. The postoperative area is represented by a soft pink scar, up to 1.0 cm. There are no hypertrophic manifestations. Elements of vascular formation are not defined. Good clinical and aesthetic result, confirmed by ultrasound

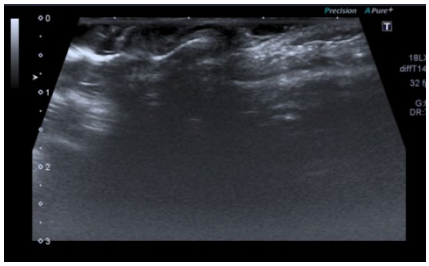


Fig. 15. The control ultrasound of the postoperative area 7 months later. The hypoechoic formation (cicatricial tissue) of 10x3mm is determined. The surrounding tissue without visible changes

FINDINGS

1. Emergency surgical treatment with interstitial selective laser photodestruction is indicated for the prevention of large blood loss in hemangiomas and pyogenic granulomas of the skin complicated by bleeding in children.

2. This method ensures the radical type of photodestruction of pathological vascular formation tissues and reliable hemostasis, which guarantees the achievement of good clinical and aesthetic results of treatment in hospitals and outpatient cases.

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