VISUALIZATION OF SOFT TISSUE COMPLICATIONS OF HEMATOMAS

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Hematoma accompanies almost all traumatic injuries of soft tissues of the human body [1]. Complications of traumatic hematomas are suppuration, fibrosis and ossification [2]. Festering process requires urgent surgery, fibrosis causes some inconvenience to the patient, and the presence of tumor causes cancerophobia, and ossification leads to a decrease in disability [3]. Diagnosis of these complications is an actual problem of radiation diagnostics. In the literature, there are few reports about the traumatic hematoma [4].

The purpose of this study is to diagnose the complications of traumatic hematomas of soft tissues with radiation methods.

MATERIALS AND METHODS

We observed 87 patients with complications of traumatic hematomas. Of these, festering hematoma was found among 21 patients (24.1%), with a transition into a hematoma fibrosis among 41 patients (47.1%), hematoma ossificans among 25 patients (28.7%) — Tabl.

There was increased pain observed clinically; redness of the skin; increase of edema; impaired function of the affected area; increase of the overall body temperature; inflammatory type of changes in blood test results. These all symptoms forced the patient to seek for medical care (Fig. 1). The clinical manifestations of the festering hematoma usually ambiguous, or often erased. Instrumental methods of investigation of traumatic hematomas of soft tissues should provide additional information on the disease process, facilitate adequate treatment.

We examined 41 patients with traumatic soft tissue hematomas which got complicated with the development of fibrosis.

Fibrosis was found after 1.5 months with 4 patients, before 3 months with 6 patients, between 3 and 7 months with 18 patients and after a year and above with 5 patients. It should be noted that the development of fibrosis, i.e. transition of hematoma into fibrosis occurs within one or one and a half months but patients seek for medical aid at different times after

Fig. 1. Suppuration hematoma in the area of lower leg

Table

Localizations of complicated hematoma by their nature and anatomical regions

Localization of the hematoma	Suppuration	Fibrosis	Ossification
Tibia	7	14	2
Thigh	9	13	19
Shoulder and forearm	3	2	4
Ankle joint		1	
Gluteal region	2	8	
STAT *		2	
Neck		1	
Total	21	41	25

* Note — soft tissue of the abdomen and thorax.

the onset of fibrotic changes of hematoma which may last for years. Patients report the presence of a palpable tumor type formation and pain. Fibrosis often has a soft elastic consistency and rarely a dense one. The fibrosis zone undergoes a certain deformation as seen in the patients' pictures presented (Fig. 2). The palpable tumor type formation caused a certain alertness of patients in terms of the tumor development.

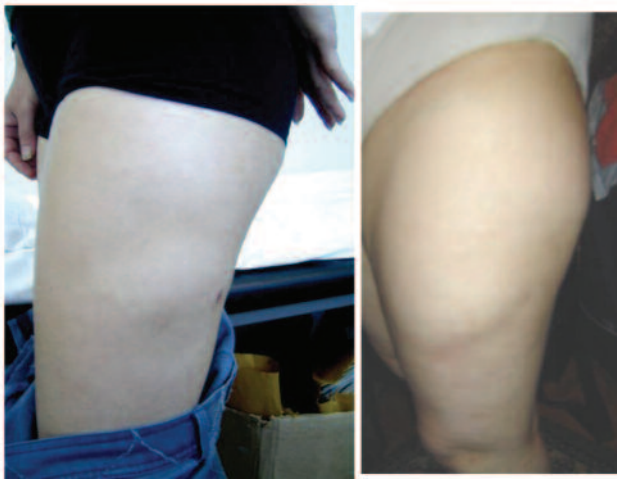

Fig. 2. The fibrotic changes in the hip area

Ossification of the hematoma is one of the complications of traumatic hematomas. On the place of the former hematoma, there occurs an ossifying process with the formation of a newly formed bone tissue of varying maturity.

Under our care, there were 25 patients who, according to their clinical history, supposed to have ossifying hematoma.

Terms of ossificates are different starting from a few weeks to 3 months. These data were elucidated in the anamnesis.

Clinical manifestations of the ossifying hematoma had no specific symptoms. The skin over the damaged area is not changed and only palpation done by the patient proved the tumor type formation to be present. There arose a pain, especially during physical activity.

An ultrasound examination was carried out with the sector or linear sensor device with an operating frequency of 3.5 MHz to 12 MHz. The sensor device selection depended on the size of a hematoma, the depth of its occurrence and the anatomical location of the hematoma area. The study was conducted with regard to the principle of poly-positionality of the study. When patients with traumas come to consult a doctor, one of the mandatory research methods, to exclude the presence of a fracture of bone structures, was radiography.

We have studied the data of ultrasound and X-ray studies of hematomas with signs of ossification. Radiography of soft tissues was performed in typical projections depending on the affected area. To clarify the nature of fibrotic changes there was MRI performed.

RESULTS AND DISCUSSION

Traumatic hematoma of soft tissues is the ideal condition for a suppurative process to develop. There are different ways for infection to enter: impaired skin integrity; lymphogenous way; iatrogenic way of introducing infection during puncture; violation of the aseptic and antiseptic principles. We have studied the ultrasound semiotics of festering hematomas. We observed 21 patients with festering hematomas of traumatic origin.

During the ultrasound studying, a festering hematoma was defined as a liquid formation. In the development of suppurative process, the amount of fluid in the cavity of the hematoma was increasing. This is due to interstitial fluid exudation, plethora of vessels and the increase of permeability of the vascular walls. Compliance of the tissues surrounding the hematoma is different and because of this, the form of the hematoma of oval-rounded shape became elongated and irregular (Fig. 3).

Purulent process led to a change in the contents of a hematoma, necrotic process was joining and the hematoma cavity was containing the tissue debris and the decomposing blood elements. The content of the hematoma was getting more liquid but there was a residue, and there appeared commissure process. These changes affected the structure of the hematoma (Fig. 4).

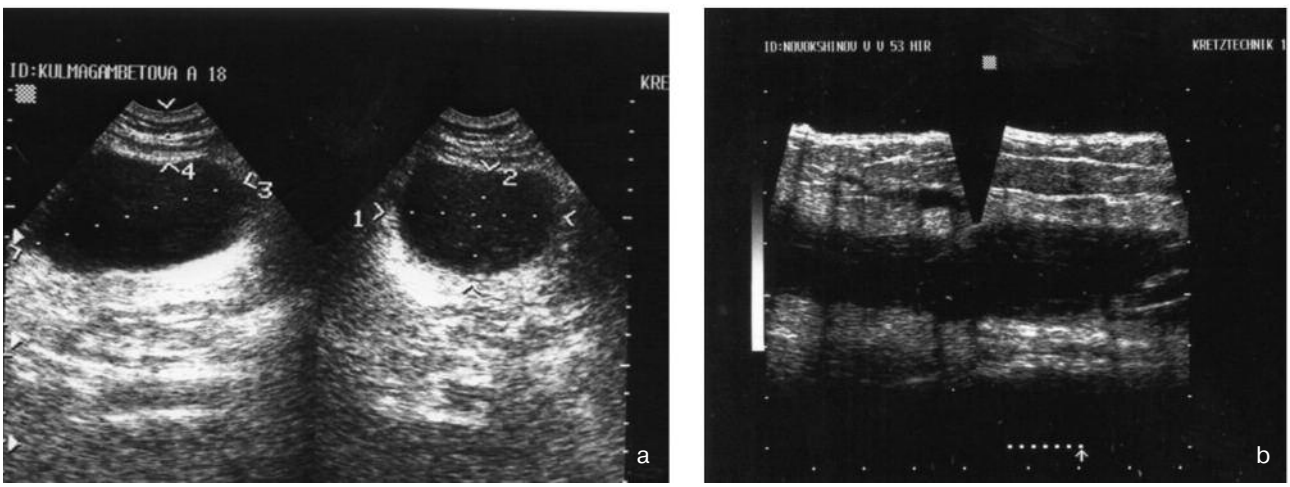

Fig. 3. Illustration of round-oval festering hematoma (**a**); Illustration of irregular hematoma (**b**)

Fig. 4. Sonogram of suppurated hematoma (**a**); suppuration of hematoma with heterogeneous structure and the presence of sediment (**b**); in the structure, there are multiple bright echo-impurities, sediment and dorsal echo-amplification (**c**)

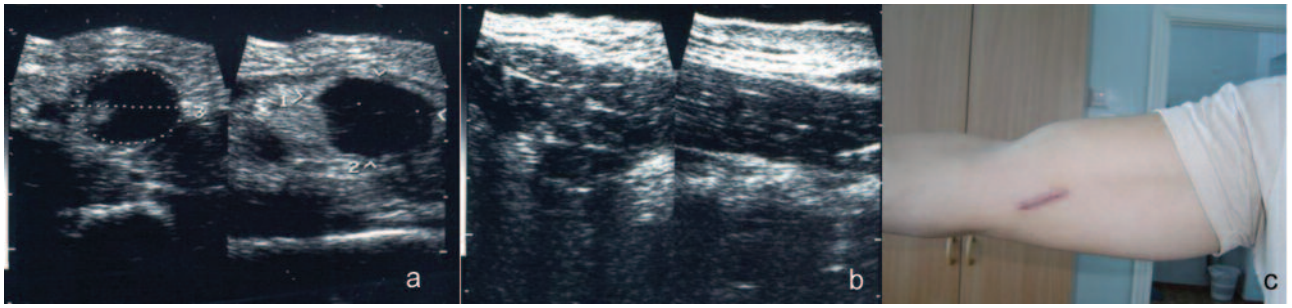

Fig. 5. Before treatment (**a**); after treatment (**b**); appearance after cure (**c**)

The contours of festering hematoma are mostly clear, and when there are capsules they could become smooth. Clarity to the contours is given by the tension of the liquid contents of the hematoma. Soft tissue swelling of various degrees depending on the depth of the hematoma was observed with all patients.

One of the highlights during the ultrasound investigation is to monitor the effectiveness of the treatment of a festering hematoma. On the example of the last checking ultrasound investigation, it is shown that a complete cure of a festering hematoma has taken place (Fig. 5).

On the sonogram (Fig. 5b), it was identified that the muscle layer was distorted, the contour was irregular and there were linear echo-impurities in the structure.

These examples illustrate the capacity of the clinical ultrasound for diagnosing and evaluating the treatment efficacy.

The sonographic analysis of our data showed that fester hematoma is presented in the form of liquid formation. At the same time sonography allows to clearly establish the depth of the festering hematoma. In this way, occurrence of hematoma in the subcutaneous fat was found in 47.6% of cases, in the intermuscular space in 52.4%. The suppurative process leads to excessive exudation of fluid that gives the hematoma rounded-oval shape in 76.2% of cases, and large sizes give irregular form (14.3%) and linear form (9.5%). Oval-round shape is mostly seen in predominant frequency. The festering hematoma is sonographically identified as an anechoic and hypo-echoic formation with the effect of dorsal echo-amplification (100%). Presence of tissue detritus, sediment, fibrotic overlays give the hematoma a heterogeneous structure (85.7%). If there is a capsule the hematoma is outlined clearly, but in the absence of a capsule, it is fuzzy (21.1%). The sonography allows to evaluate the effectiveness of both surgical and conservative treatment.

Diagnosis of ossifying hematoma

We observed 25 patients with anamneses who previously had had traumatic hematoma of soft tissue which got complicated. Absence of visible changes in the skin, questionable results of palpation forced us to send the patient to X-ray and ultrasound investigation.

During ultrasound investigation, the sonographic picture of the ossifying hematoma depended on the degree of the newly formed bone maturity. The bone tissue on the sonogram is presented as an echo-dense formation giving an acoustic shadow behind it. The apparent differences in the reflectivity of the newly formed tissues compared to the soft tissue surrounding the hematoma increase the contrast range. When the disease duration is 1.5 months, in the initial stages of the formation of ossifying myositis, the sonographic picture is presented in the form of separate clumps of echo-dense formations with jagged, sharp contours giving a weak acoustic shadow behind them (Fig. 6).

The shape of them was irregular with heterogeneous structure and increased echogenicity exceeding the echogenicity of the soft tissue around them. At the same time, it was clearly observed that there was absorption of sound waves by the ossification portions. X-ray examination at this stage is ineffective since the portions of ossification are not visualized.

Foci of ossification were locating in the thicker muscle tissue, in no case the subcutaneous tissue ossifications were identified. During ultrasound investigation, ossifying myositis is detected earlier than X-ray examination, it is especially important for timely treatment. With the lapse of time, the ossifying hematoma becomes denser as a linear echo-dense formation giving an apparent acoustic shadow but some separate clumps get merged.

Contours of the ossifying hematomas are rough, clearly seen, the structure becomes inhomogeneous with multiple areas of increased echogenicity which

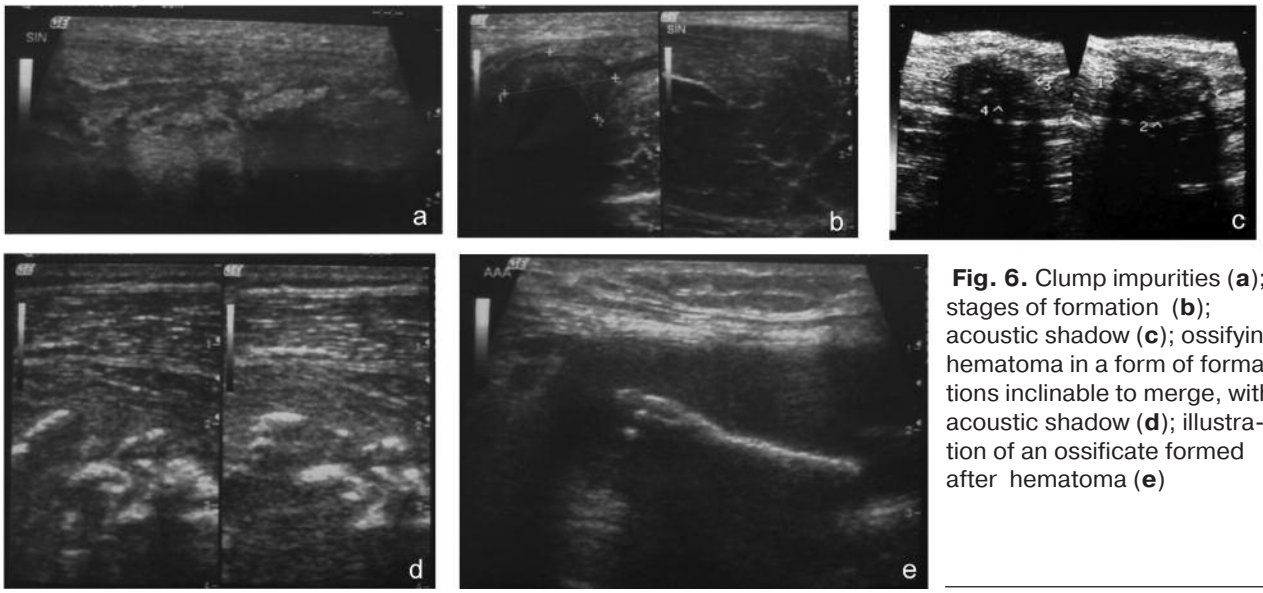

Fig. 6. Clump impurities (**a**); stages of formation (**b**); acoustic shadow (**c**); ossifying hematoma in a form of formations inclinable to merge, with acoustic shadow (**d**); illustration of an ossificate formed after hematoma (**e**)

are separated from each other by hypoechoic layers. Ultrasound has the ability to penetrate and bounce from allowing to explore the inner echo-structure of the areas of calcification. In later stages, the ultrasound does not penetrate deep into the ossified areas and is reflected and absorbed in the most superficial layers of the ossificate so the inner structure is not available for investigation.

In the tissues around the ossificate, there were found a hypoechoic rim which is a result of aseptic inflammatory process with hyperaemia and vasodilatation. According to our data hypoechoic rim is clearly visualized in the later stages of the formation of ossificate. In the initial stages, the hypoechoic rim is thin. In the stage of ossificate, the hypoechoic rim as separate clumps is not visualized. The appearance of broad hypoechoic rim around the ossification is a result of injury of the muscle tissue around.

During X-ray examination, in the initial stages of ossifying hematoma, there were not found changes in the muscle tissue. At the same time, the radiography allowed to identify the shape, size, contours and structure of ossificate in the already formed ossifying hematoma.

With ultrasound, we identified multiple foci of calcification in the form of separate fragments which cause difficulty during their complete removal. Ultrasound allows to evaluate the radicality of surgical intervention and complements the X-ray picture, also, reveals an ossifying hematoma in various stages of ossification. Sonography is far superior with its resolving power than X-ray method in the diagnosis of ossifying hematoma and with its ability as a method on itself to solve the problem of diagnosing this pathology.

Analysis of the results of the study showed that during sonography, the ossifying hematoma looks like an echo-dense formation which is localized in the muscular layer in 100% of cases. The shape of the ossification was often irregular in 64% of cases, rarely linear in 20% or as separate clumps in 16% depending on the stage of its formation. Ossification may be multiple in 52% of cases and single 48%. Its contours are clear and uneven in 100% of cases. Its structure is homogeneous in 28% of cases and inhomogeneous in 72% depending on the stage of formation of fibrosis. It is typical for ossification to have medium echogenicity in 12% and high echogenicity in 88% of cases. An acoustic shadow was detected in 88% of cases. Hypoechoic rim as a sign of inflammatory infiltration was found in 76% and myositis in 68% of cases.

Echo-semiotics of hematoma complications with the transition to fibrosis

Hematoma is not always completely absorbed, during surgery, traumatologists often see that a hematoma starts to turn into a delicate connective tissue. With timely treatment, the tissue is partially absorbed, but it may have a tendency to grow. Such changes may locate in any area of a patient's body. With their clinical appearances, fibrosis is similar to a benign tumor. The general network doctors' lack of awareness about fibrotic changes in soft tissues after hematoma leads to the fact that the patient does not receive timely treatment. During the ultrasound investigation, 42 patients were found to have fibrotic changes after hematoma. On the former site of hematoma at its earliest manifestations, the fibrosis were found with 10 people after 1.5 months up to one year, with one patient after more than one year, and with one patient after over 5 years.

Ultrasound picture of changes in the fibrosis differs from the stage of its formation. In the initial stages of formation of a hypoechoic hematoma resembles in accordance with growth of connective tissue its echogenicity increases and is found as a tissue formation.

Fibrotically changed parts of the soft tissues had rounded-oval or irregular shape. So oval-rounded form was observed with 30 patients (71.4%), and was irregular with 12 patients (28.6%), the form of fibrosis follows the shape of the hematoma.

Fibrotic areas were basically defined as single formations, but in a few cases there were also multiple ones.

Contours of a formation may be clear, rough and bumpy. Clear contours were detected with 15 patients (35.7%), uneven and bumpy ones were with 24 patients (57.1%). Smooth clear contour was detected

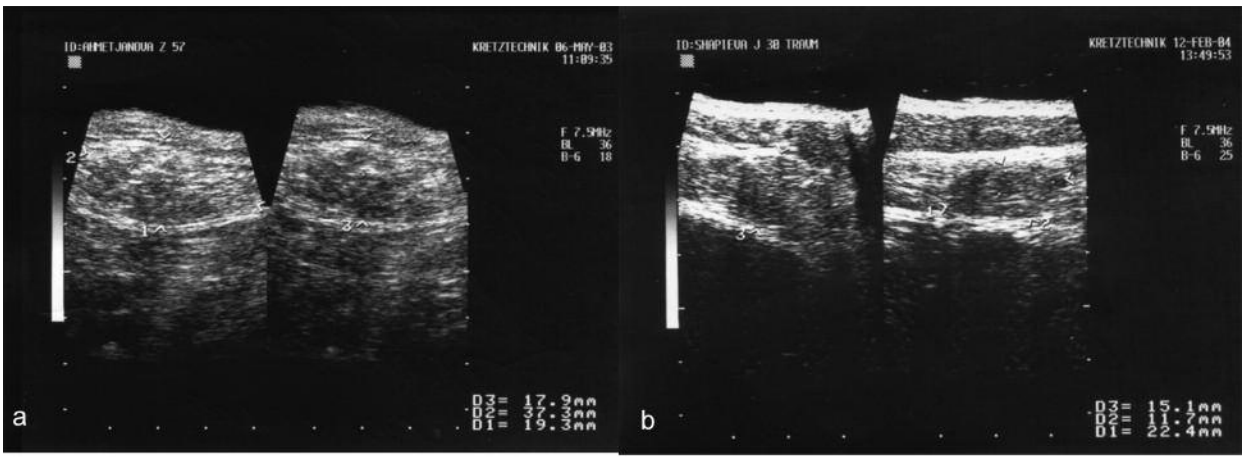

Fig. 7. Localization and fibrosis: subcutaneous fat (**a**); intermuscular (**b**)

with 3 patients (7.2%). It is typical for fibrosis to have clear contours which are uneven and bumpy.

Dimensions of fibrosis ranged from 3 to 5 cm and above. At initial stages of fibrosis, its echogenicity is reduced and it is similar to a liquid formation, but unlike liquids it has no effect of dorsal echo-amplification.

During the ultrasound investigation, it was noticed that hypoechoic areas of fibrosis absorb more sound waves than they reflect them. In the process of fibrosis formation, its reflecting ability increased and became isoechoic or high echoic. Echogenicity around the edges of the emerging fibrosis is higher but lower in the center. Apparently, this is due to the fact that the fibroblasts begin to form fibrosis from the periphery to the center. The fully formed fibrosis has an increased echogenicity on the sonogram.

According to our data, the structure of fibrosis was homogeneous with 10 patients (23.8%) and inhomogeneous with 32 patients (76.2%).

Fibrosis formed in the thickness of a muscle tissue had an inhomogeneous structure in the form of linear echo-impurities similar to muscle fibers. In the structure of fibrosis, we saw the areas of calcination giving the effect of an acoustic shadow. These data indicate that portions of heterotopic ossification may be formed in the area of fibrosis. The semiotics described above is presented in Figure 8.

As an example below is given an observation over the patient N., 15 years old who has had a fibrosis as a tumor type formation after 5 years after injury. The patient underwent ultrasound investigation, MRI and there was given a conclusion of fibrotic changes (Fig. 9).

Thus, X-ray, ultrasound and MRI are used in diagnosing a fibrosis.

Analysis of the study shows that sonography allows to reveal fibrotic changes after traumatic hematoma and to characterize those changes. It has been found that fibrosis was localizing in subcutaneous fat in 50% of cases, intermuscular — 38.1%, in all the layers — 11.9%. The form of the fibrosis was oval-round, with the number of single or multiple ones. The contours were clear, rough and hilly (92.8%). The sizes were up to 5 cm (73.8%) and more than 5 cm (16,7%). The structure was homogeneous in 23.8% of cases and inhomogeneous in 76.2%. On the background of fibrotic changes area, the ossified foci were detected in 7.1%.

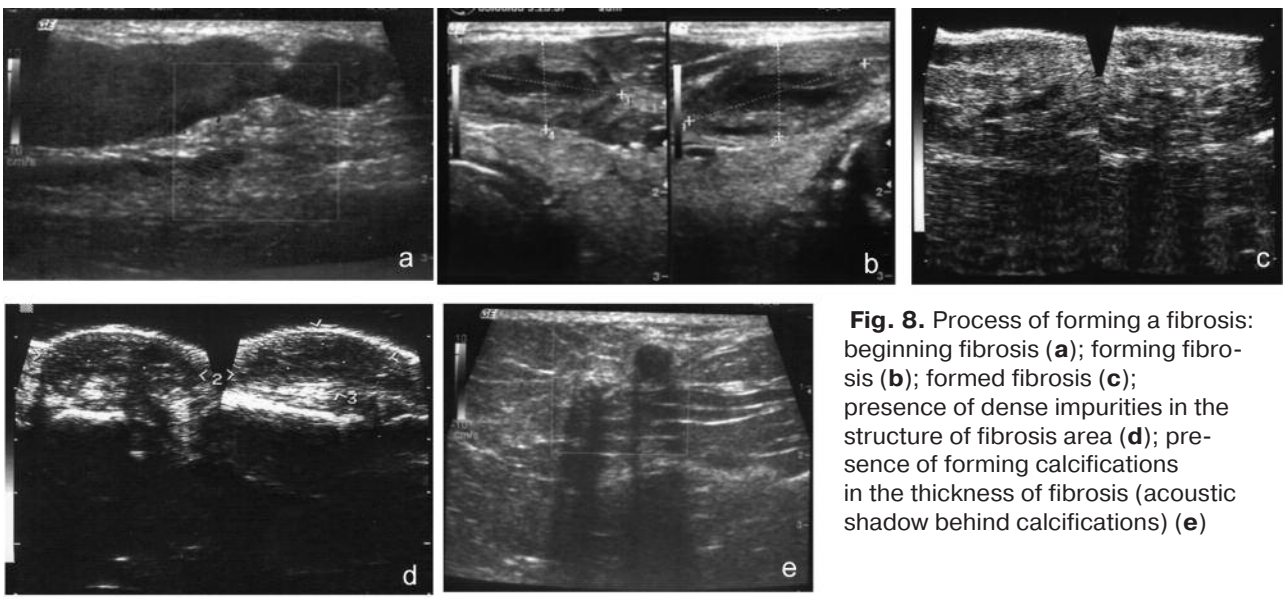

Fig. 8. Process of forming a fibrosis: beginning fibrosis (**a**); forming fibrosis (**b**); formed fibrosis (**c**); presence of dense impurities in the structure of fibrosis area (**d**); presence of forming calcifications in the thickness of fibrosis (acoustic shadow behind calcifications) (**e**)

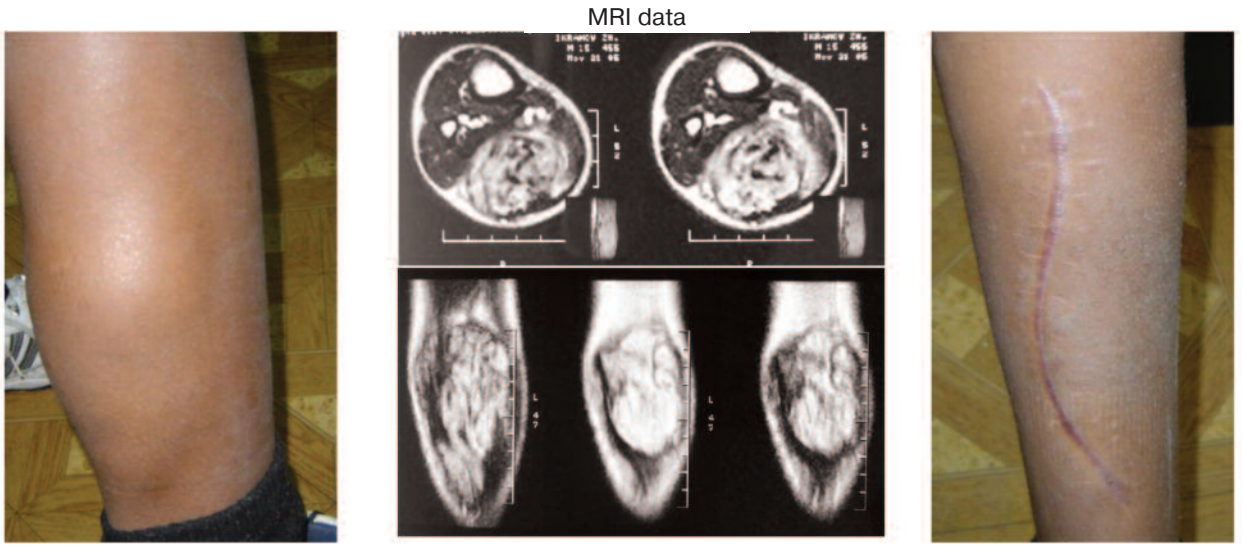

Fig. 9. Before treatment (**a**); after operation (**b**)

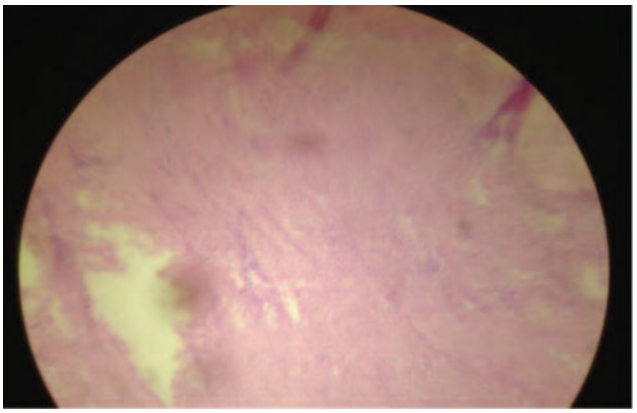

Fig. 10. Histologic specimen of fibrotic changes

CONCLUSIONS

1. The sonographic method of investigation allows to reveal complications such as hematoma suppuration and features of its manifestation as well as to evaluate the effectiveness of surgical and conservative treatment.

2. Sonography allows to reveal an ossifying hematoma, and the sonographic signs are really convincing and almost specific so it diagnoses earlier than the X-ray examination. The ultrasound examination allows you to identify the stage of formation of ossification.

3. During sonography, the dependence of the semiotics on the formation stage of fibrosis. In the initial stages of formation, more hypoechoic resembles the hematoma, as the connective tissue was growing around (it), its echogenicity was rising and fibrosis was similar to a tissue formation.

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VISUALIZATION OF SOFT TISSUE COMPLICATIONS OF HEMATOMAS

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***Summary**. The results of visualizatio of 87 patients with soft tissue hematoma complications such as suppuration, fibrosis and ossification are given. While diagnosing these complications, a comparative analysis of imaging techniques — X-ray, ultrasound and MRI – were conducted. Diagnostic capabilities of each of these methods were established. Sonography is the method of choice due to the simple techniques, the possibility of multiple usages, high self-descriptiveness. Sonographic signs of ossification, fibrosis and suppuration were studied.*

ВІЗУАЛІЗАЦІЯ УСКЛАДНЕНЬ ГЕМАТОМ М'ЯКИХ ТКАНИН

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***Резюме**. У статті наводяться результати візуалізації ускладнень гематом м'яких тканин у 87 хворих, таких як нагноєння, фіброз і окостеніння. При діагностиці цих ускладнень, було проведено порівняльний аналіз методів — рентген, УЗД та МРТ-візуалізації. Діагностичні можливості кожного з цих методів були встановлені. Сонографія є методом вибору через простоту методу, можливість проведення великої кількості досліджень, високу інформативність. Були вивчені сонографічні ознаки окостеніння, фіброзу і нагноєння гематом м'яких тканин.*

ВИЗУАЛИЗАЦИЯ ОСЛОЖНЕНИЙ ГЕМАТОМ МЯГКИХ ТКАНЕЙ

Мухамедянов К.Х., Амиров Б.Б., Адилбаєв Г.Б., Лі Е.Л., Абеков А.К,

***Резюме.** В статье приведены результаты визуализации осложнений гематом мягких тканей у 87 больных, а именно: абсцессов, фиброза и окостенения. При диагностике этих осложнений был проведен сравнительный анализ методов - рентгеновского, ультразвукового и МРТ. Изучены диагностические возможности каждого из этих методов. УЗИ является методом выбора благодаря простоте метода, возможности многократного исследования, высокой информативности. Были изучены сонографические признаки окостенения, фиброза и нагноения при гематомах мягких тканей.*