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Power Doppler usage for early diagnostics and follow up of post-traumatic myositis ossificans: a case report

Upotreba power Dopplera za rano otkrivanje i praćenje posttraumatskog osificirajućeg miozitisa: prikaz bolesnika

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Summary

The purpose of this case report is to describe the phases of the post-traumatic myositis ossificans (PTMO) by using high resolution ultrasound (HRUS), power Doppler, radiography and multislice computed tomography (MSCT). The case report is based on a spastically quadriplegic 17-year-old patient who developed PTMO of both hips and shoulders after a severe traumatic brain injury (TBI). The follow up consisted of using imaging methods 3, 6 and 9 months after injury. In the early stages of the PTMO, the high-resolution ultrasound (HRUS) in B mode showed heterogeneous areas with surrounding hypoechoic soft tissue and hyperechoic core. Positive power Doppler signal was also detected. With the maturing of the lesions, a peripheral lamellar calcification and posterior acoustic shadow became visible, along with positive power Doppler signal. The lesions, which show a completely calcified periphery with acoustic shadow and negative power Doppler signal, are considered mature. In our study, we noted the positive power Doppler signal in the first and second stage of the follow up, while it was negative 9 months after the injury. The ultrasound examination is especially useful in the early stages, when there is no positive signal on radiograms, and in estimating the maturity of the lesion. We recommend the usage of the power Doppler for early diagnosis and the estimation of the maturity of the ossification.

Key words: post-traumatic myositis ossificans, power Doppler, ultrasound, radiography, computed tomography

Sažetak

Cilj ovoga prikaza je opisati faze post-traumatskog osificirajućeg miozitisa (PTMO) pomoću ultrazvuka i power Dopplera, radiografije i višeslojne kompjuterizirane tomografije. U studiji je praćena 17-godišnja bolesnica sa spatičnom tetraplegijom, nakon teške traumatske ozljede mozga kojoj je dijagnosticiran PTMO oba ramena i oba kuka. Praćenje je provedeno u tri vremenske točke -3, 6 i 9 mjeseci nakon traume. Ultrazvučnim prikazom u B modu lezije u ranim fazama PTMO vide se kao heteroehogena područja s hipoehogenim okolnim mišićem i žarištima hiperehogenosti, uz pozitivan nalaz power Dopplera. Kako lezija sazrijeva vide se periferne lamelarne kalcifikacije s pozitivnim nalazom power Doppler. Lezije s potpuno kalcificiranom periferijom, akustičnom sjenom i negativnim nalazom power Dopplera smatraju se zrelima. U našoj studiji zabilježili smo pozitivan power Doppler u prvoj i drugoj fazi praćenja, dok je nalaz power Dopplera 9 mjeseci nakon ozljede bio negativan. Ultrazvuk je posebno koristan u ranim fazama kada još uvijek nemamo pozitivan nalaz na radiogramima i također je koristan za procjenu zrelosti lezije. Predlažemo upotrebu power Dopplera za rano otkrivanje i procjenu zrelosti osifikata.

Ključne riječi: posttraumatski osificirajući miozitis; power Doppler; ultrazvuk; radiografija; kompjuterizirana tomografija

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Introduction

The post-traumatic myositis ossificans (PTMO) is a benign, progressive, ossificating lesion. It is a localized formation of heterotopic bone in muscles where it does not usually exist. In most cases, the history of prior, repeating micro/macro trauma is present.[1] It is important to differentiate myositis ossificans from sarcomatous changes and metastatic calcifications, and to determine the maturity stage of the lesion.[2,3] The maturity stage of the lesion determinates further medical intervention and treatment. PTMO is commonly seen in patients with central nervous system impairments (traumatic brain injury (TBI), tumors, encephalitis, spinal cord injuries), and post-surgical complication also.[4] Although it is difficult to predict the development of neurogenic heterotopic ossifications, it is positively correlated with the severity of brain damage. The most commonly involved localization is the hip.[5] In context of central nervous pathology, periarticular ossification is most commonly found.[1] PTMO is typically found in the muscles, but it can also occur in the tendons, joint capsules, ligaments and fascia.[6] Symptoms of PTMO include edema, pain, soft tissue swelling, palpable mass in affected area and restriction of movement and functions.[7] The clinical signs and symptoms of heterotopic ossification can develop from 3 to 12 weeks after a musculoskeletal injury, spinal cord injury or another precipitating factor.[4] Clinical suspicion of PTMO could be set up in case of posttraumatic progression of pain and reduction in range of motion in the joint, not showing improvement on physical and conservative therapy.[8] Imaging methods are better than a biopsy for the evaluation of the PTMO lesion maturity and are crucial for early intervention. The purpose of this study is to describe a course of diagnosing PTMO formation by using power Doppler in a 17-year-old female patient after severe traumatic brain injury. The overall diagnostic and follow up tools consisted in using high resolution ultrasound (HRUS), power Doppler, plain radiography and multi-sliced computed tomography (MSCT) 3 months, 6 months and 9 months after TBI. During the study, besides using imaging methods, the measurement of the laboratory parameters was performed (C-reactive protein [CRP], alkaline phosphatase [AP], D dimmers, fibrinogen). Vanden Bossche and his colleagues reported in their study that the value of alkaline phosphatase 4 weeks after injury could be 3.5 times higher than normal, with the peak concentration about 12 weeks after trauma.[4]

Ultrasound examination was performed on Siemens-Acuson X500 with linear probe frequency 5-13 MHz using power Doppler to verify flow. MSCT was made on Siemens-Emotion 16 device.

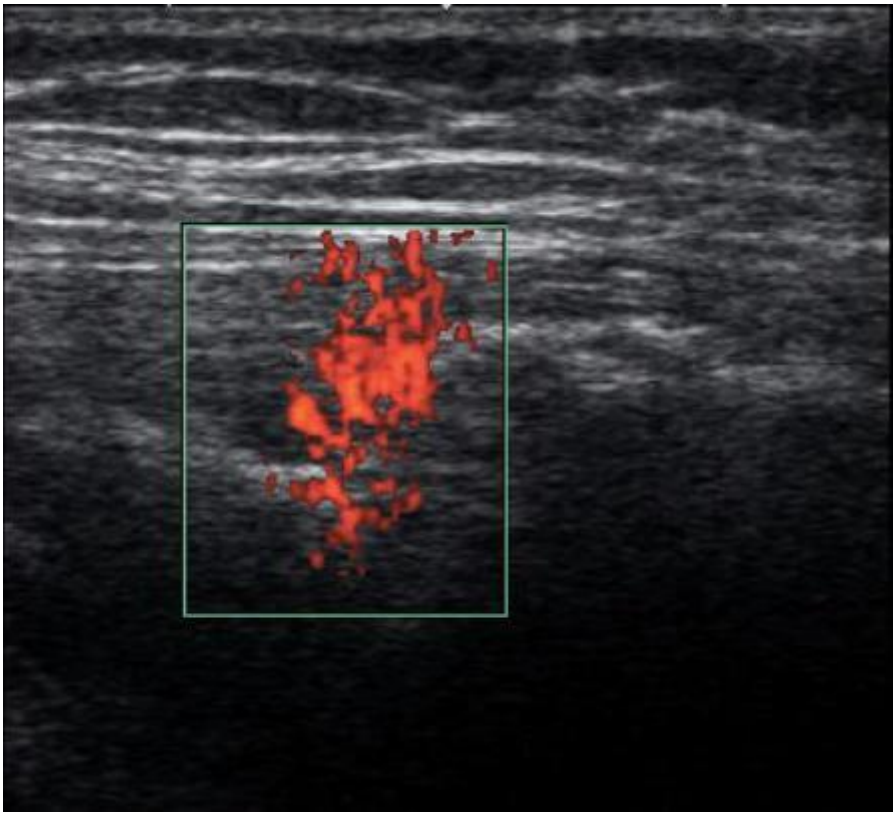
Case presentation

A 17-year-old female patient was admitted at Children's Rehabilitation Department 3 months after severe TBI and acute treatment. The patient was in vigil coma (Glasgow Coma Score, GCS=8) with severe spastic quadriparesis. Two weeks after admission, the rise in laboratory parameters was verified without any change in clinical or neurologic status. In the following two weeks, we noticed a painful reaction of the patient to movement in the right leg. Clinical examination of the patient showed a swelling and a painful palpable mass in the proximal part of the right thigh, restriction of range of motion in all directions with almost blocked passive movement of both hip and shoulder. Three months after TBI (phase I), high resolution ultrasound (HRUS), power Doppler (Siemens), plain radiography and multi-sliced computed tomography were performed as diagnostic modalities. The follow up consisted of using the same imaging modalities after 6 months (phase II) and after 9 months from the TBI (phase III).

Table 1 Imaging findings in posttraumatic myositis ossificans
Tablica 1 Slikovni nalazi u posttraumatskom osificirajućem miozitisu

Phase *Faze*	Time *Vrijeme*	Plain film *Radiografija*	Ultrasound *Ultrazvuk*	Power Doppler	MSCT *Kompjuterizirana tomografija*
Phase I/early *Faza I / rana* 1st monitored time point/ *1.vremenska točka praćenja*	3 months after injury *3 mjeseca nakon ozljede*	Soft tissue swelling *Otok mekog tkiva*	Heterogeneous hypoechoic soft tissue masses with hyperechoic core *Hetroehogena-hipoehogena mekotkivna masa s hiperehogenom jezgrom*	Positive power Doppler signal *Pozitivan nalaz power Dopplera*	Soft tissue swelling; peripheral calcified rim *Otok mekog tkiva, periferni kalcificirani rub*

Phase II/ subacute *Faza II/ subakutna* 2nd monitored time point / *2. vremenska točka praćenja*	≥6 months after injury *≥6 mjeseci nakon ozljede*	Well-defined peripheral calcification *Dobro definirana periferna kalcifikacija*	Hipoechoic areas with hiperechoic, irregular periphery *Hipoehogeno područje s hiperehoegenom iregularnom periferijom*	Positive power Dopplera signal *Pozitivan nalaz power Dopplera*	It was not used at this stage *Nije rađen u toj fazi*
Phase III/ mature *Faza III/* Zrela 3rd monitored time point/ *3. vremenska točka praćenja*	>9 months after injury *>9 mjeseci nakon ozljeda*	Densely calcified lesion *Gust kalcifikat*	Highly reflective, heavily calcified lesion *Visoko reflektirajuća, jako kalcificirana lezija*	Negative power Doppler signal *Negativan nalaz power Dopplera*	Dense ossification *gust osifikat*



Picture 1 High resolution ultrasound (HRUS) image shows hypo to hyperechoic area with loss of orientation of muscle fibers including positive power Doppler signal, anteromedial view of the right hip
Slika 1 Ultrazvučni prikaz hipo do hiperehogenog područja s gubitkom fibrilarne strukture mišića i pozitivnim nalazom power Dopplera, anteromedijalni prikaz desnog kuka

Phase I: High resolution ultrasound of the right thigh showed inhomogeneous tissue at anterior and lateral sides with loss of orientation of muscle fibers. Positive power Doppler signal was detected (Picture 1). HRUS of shoulders detected a blurred, heterogeneous zone with the loss of fine fibrillary structure of the affected muscles and hypoechoic surrounding muscles. The power Doppler showed increased vascularization at the periphery of the affected area. Two weeks later plain, anteroposterior radiographs of the pelvis showed

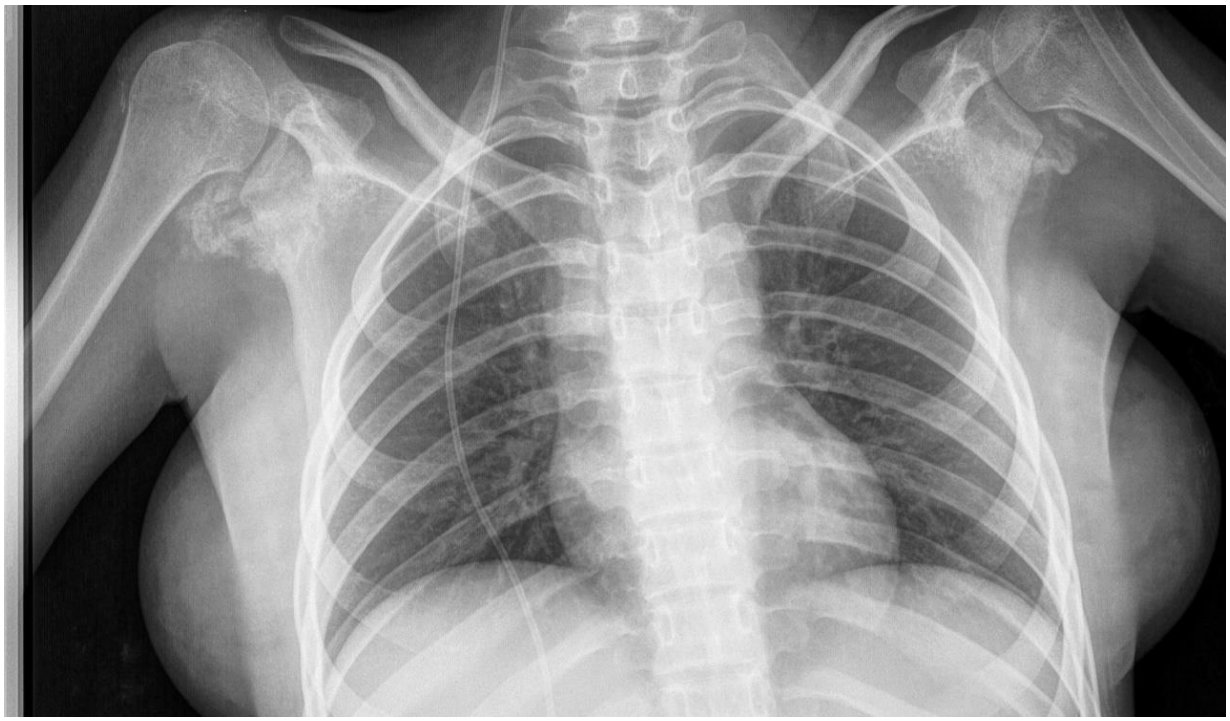
poorly organized calcification next to the iliac bone on the right side and the edema of the soft tissue surrounding the neck of the left femur (Picture 2).

Picture 2 Anteroposterior radiographs of pelvis and hips show calcificates next to iliac bone on both sides, and left sided edema of the soft tissue
Slika 2. Anteroposteriorna radiografija zdjelice s kukovima pokazuje obostranu kalcifikaciju uz ilijačnu kost i edem mekoga tkiva na lijevoj strani

Radiographs of both shoulder visualized mineral shadows in the soft tissue (Picture 3). Multi-sliced computed tomography of the pelvis verified heavily calcified muscles by the right iliac bone, including the muscles attached to the proximal femur (m. iliopsoas, m. quadriceps). In left m. iliopsoas and the surrounding soft tissue ossificated deposits with hypodensity (edema) around the lesion were detected. In both piriform muscles, small deposits were detected spreading to gluteal musculature on the left. The left obturator muscle also showed small ossificated deposits (Picture 4).

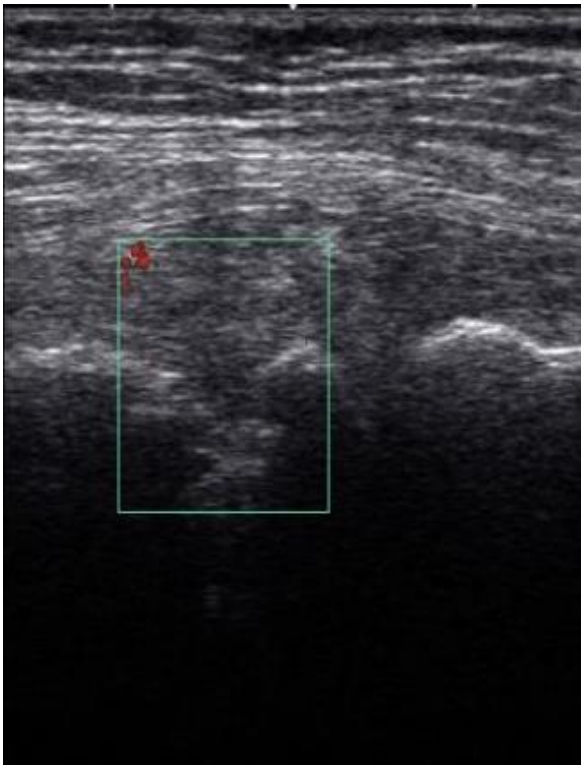
Phase II: HRUS of the pelvis and proximal thigh bone both-sided using lateral aspect showed linear, hyperechoic, interrupted and thick areas with acoustic shadowing. The power Doppler signal was negative.

The anterior and anteromedial aspect showed hypoechoic areas with hyperechoic, irregular periphery. The power Doppler signal detected increased vascularization (Picture 5). The anterior aspect of both shoulders showed poorly defined, 17.5x 7.5 mm on the left and 23.1x 7.5 mm on the right, inhomogeneous hyper to hypoechoic tissue surrounded with hypoechoic zone of edema. The power Doppler signal was highly positive (Picture 6).



Picture 3 Radiographs of both shoulders show pale peripheral calcifications
Slika 3. Radiografija oba ramena pokazuje blijede periferne kalcifikacije

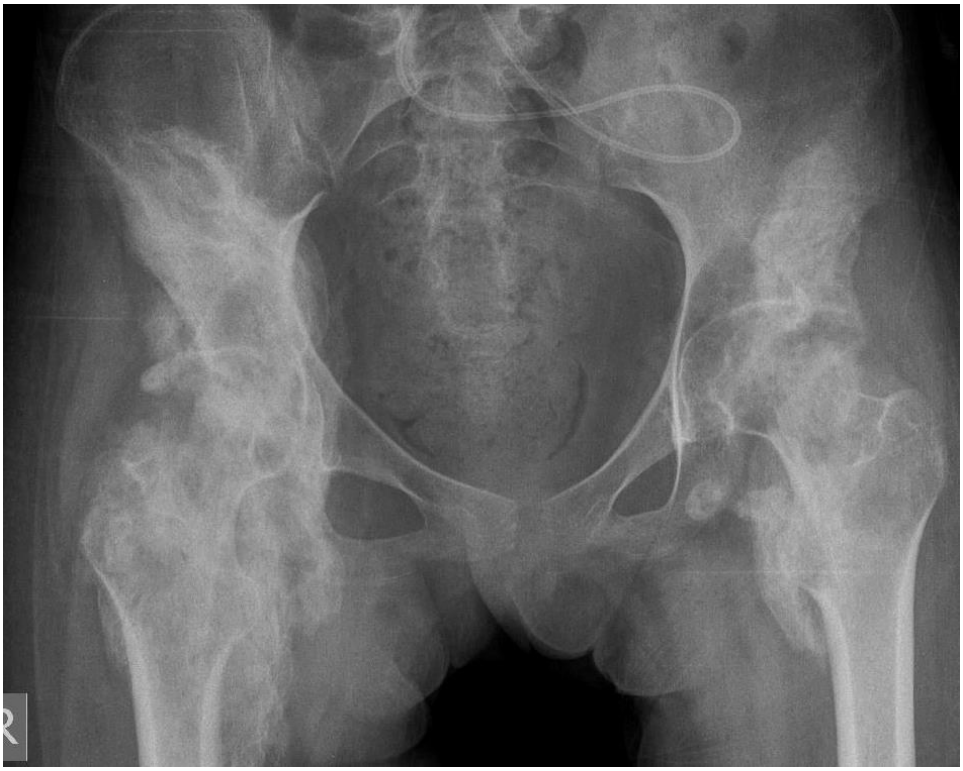
Picture 4 MSCT of pelvis with hips shows both-sided soft tissue edema and pale calcifications
Slika 4. MSCT zdjelice s kukovima pokazuje obostrano edem mekoga tkiva i nježne kalcifikacije



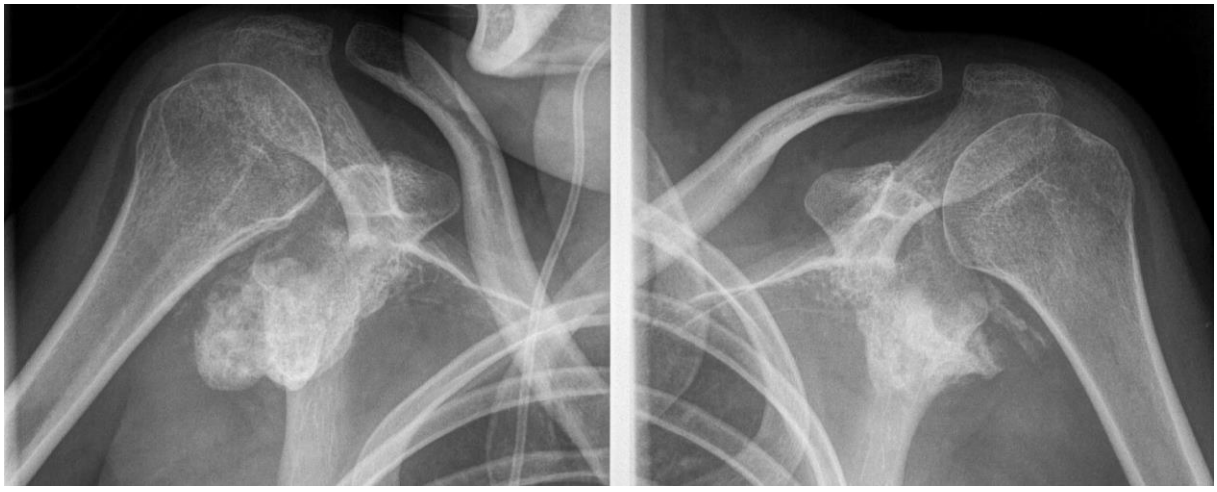
Picture 5 Hip HRUS; anterior and anteromedial aspect shows hypoechoic areas with hyperechoic, irregular periphery including positive power Doppler signal
Slika 5. UZV kuka: u prednjem anteromedijalnom prikazu vidi se hipoehogeno područje s hiperehogenom iregularnom periferijom i pozitivnim nalazom power Dopplera

Picture 6 Shoulder HRUS anterior aspect shows hyper to hypoechoic area of mixed echoicity surrounded with hypoechoic zone of edema
Slika 6. UZV ramena u prednjem pristupu pokazuje hiper do hipoehogeno područje miješane ehogenosti okruženo s hipoehogenim područjem zone edema

Radiographs showed deposits of ossification of the hip and shoulder region with well-defined peripheral calcification. In comparison to previous radiographs, progression in the size of ossificated deposits was detected (Picture 7, 8). Both imaging methods (HRUS and radiographs) showed enlargement in the size of the deposits and organization leading to a progression of the process itself.



Picture 7 Radiograph of pelvis with hips – extensive ossifications in hip area
Slika 7. Radiografija zdjelice s kukovima – masivne osifikacije u regiji oba kuka

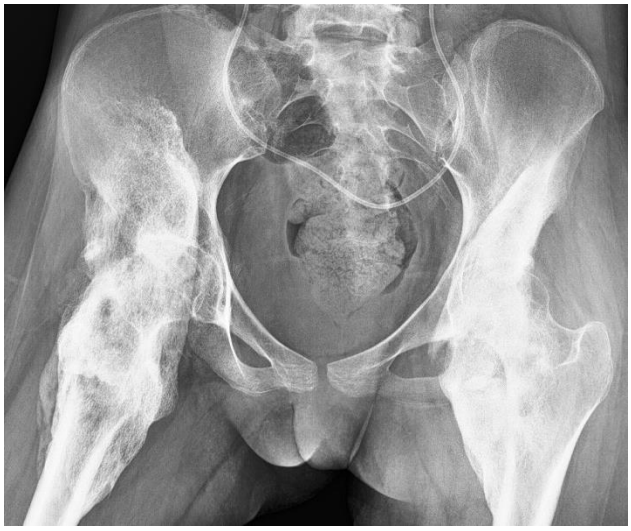


Picture 8 Radiographs of both shoulder – well-defined soft tissue calcifications
Slika 8 Radiografija oba ramena – dobro definirane kalcifikacije

Phase III: Hip and shoulder region HRUS detected linear, hypoechoic, interrupted, thick areas with acoustic shadow and negative power Doppler signal (Picture 9).

Picture 9 Shoulder; anterior aspect – linear, hyperechoic, interrupted areas with acoustic shadow
Slika 9. Rame – prednji prikaz – linearna hiperehoegena isprekidna područja s akustičnom sjenom

Radiographs of the pelvis and shoulder showed mature and dense calcification (Picture 10, 11a, 11b).



Picture 10 Radiograph of pelvis with hips – mature, dense calcification with sharp margins
Slika 10. Radiografija zdjelice s kukovima – gust kalcifikat oštrih rubova

Picture 11 Radiographs of both shoulders (a, b)
Slika 11 Radiografija oba ramena (a, b)
a) right shoulder – mature ossification
a) desno rame – zrel osifikat

b) Left shoulder – nearly complete regression of ossificating lesion
b) Lijevo rame – gotovo potpuna regresija osifikata

In the final phase, MSCT of the pelvis showed dense calcification in the muscles by the iliac bone and the proximal femur (Picture 12).

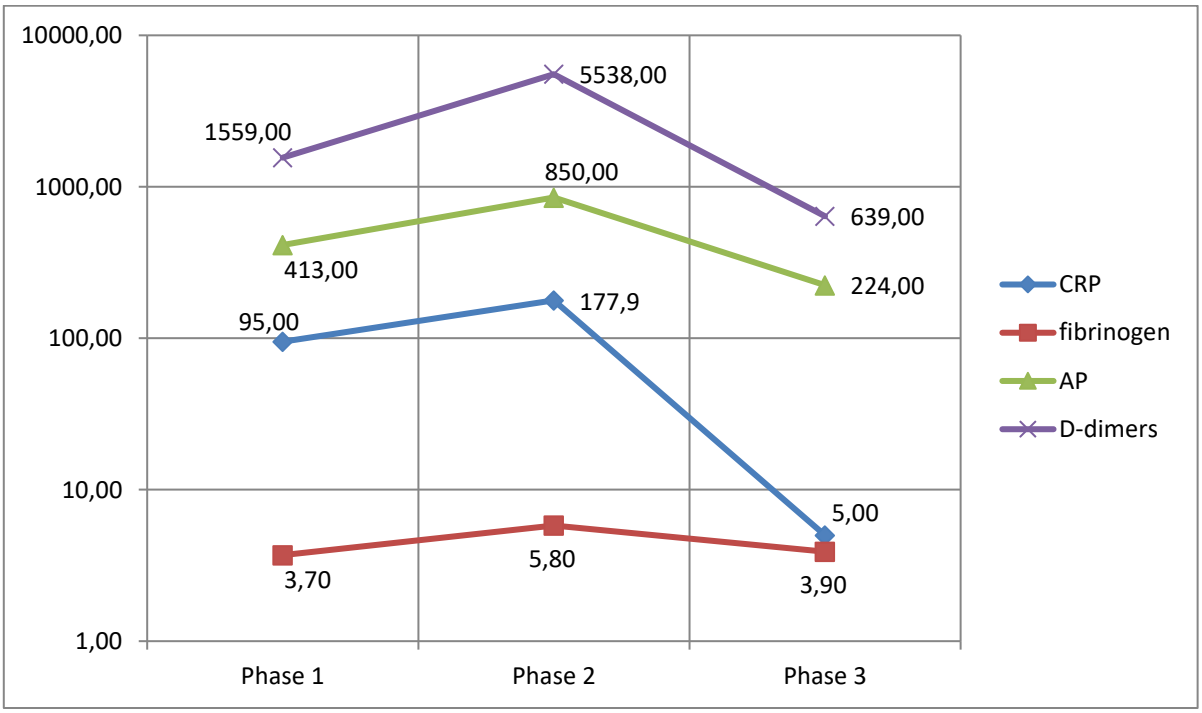
Laboratory parameters verified a rise of CRP in the first two phases (maximal value 177 mg/l), alkaline phosphatase (maximal value 850 U/l), d-dimers

(maximal value 5538 ng/ml), fibrinogen (maximal value 5.8 g/l). The end phase (III) detected a fall of all four laboratory parameters (Picture 13).

After diagnosis was made, non-steroidal anti rheumatic drugs (NSAR) were added. Indomethacin was prescribed in the initial dose of 150 mg per day for 10 days, followed by a maintenance dose of 75 mg per day until the end of the process of maturation of the deposits.

During rehabilitation, we performed individual kinesiotherapy, exercises of passive joint mobilization and positioning, and applied static splints to prevent the development of further contractures.

Picture 12 MSCT of pelvis shows extensive ossifications both-sided in the final phase of formation
Slika 12. MSCT zdjelice pokazuje ekstenzivne obostrane osifikate u završnoj fazi



Picture 13 Values of laboratory parameters
Slika 13. Vrijednosti laboratorijskih nalaza

Discussion

Ultrasound is the most sensitive diagnostic modality with the possibility of detecting the early phase of PTMO, before calcifications are seen on plain radiographs. HRUS assesses lesion maturity. The early phase of HRUS shows central hypoechoic lesion with lamellar, hyperechoic, poorly defined periphery so called "zone phenomenon".[1] In our experience, since the HRUS is positive two to three weeks prior to other imaging modalities, appropriate treatment is possible due to early diagnosis. The mature phase of PTMO shows lace, radiographic areas with cloudy ossificates. The progression of the lesion shows a radiopenic center not connected to the adjacent bone, called "cleavage plane".[9] The MSCT precisely demonstrates cross-sectional zonal pattern of calcification which enables the determination of the exact position in relation to the surrounding organs and blood vessels which is very important prior to surgical treatment.[10] The MSCT visualizes small lesions undetectable with plain radiographs. The radionuclide bone scan does not give precise assessment of the size and differentiation of the lesion from the surrounding tissue.[11]

In our patient, spontaneous regression of ossificates lesions is detected. Early and precise diagnosis is crucial for planning medical treatment of PTMO. The HRUS is highly sensitive for early diagnosis of PTMO and differentiating PTMO from soft tissue tumors.[12] In sarcoma, calcification formation begins in the center and progresses toward the periphery of the lesion, while in PTMO calcification first develops in the periphery.[13] Deposits were not limited by anatomical boundaries and structures and were found in several of them.

Ultrasound is particularly useful in the early stages, prior to positive findings of calcifications on plain radiographs to evaluate lesion maturity. Early PTMO lesions are seen as heteroechoic areas with hypoechoic surrounding muscles and hyperechoic changes in the center of the lesion including positive power Doppler signal. As the lesion matures, linear hyperechoic areas with dorsal acoustic shadow are seen and the hyperechoic periphery of the ossificate is irregular. Lesions with completely calcified periphery and acoustic shadow including negative power Doppler signal are considered mature. Higher maturity of the lesions brings less possibility of recurrence after surgical excision.

In the acute and the intermediate phase of formation of the ossificates, a positive power Doppler signal was detected. In the mature phase, the power Doppler signal was negative.

The value of the research is a comparison of the different imaging methods used in the monitoring of this patient, and the comparison of the phases of the disease. Moreover, we have not found a similar case in available literature where ossification simultaneously occurs on 4 localizations. Furthermore, we have not found a study which compares the evolution of those three phases by follow up performed by three different imaging methods: ultrasound examination, power Doppler and CT.

We suggest the usage of HRUS combined with power Doppler for early PTMO detection and for maturity evaluation. Radiography and MSCT have low specificity in early stage PTMO. Low cost, noninvasive approach, device mobility, precision and accuracy of HRUS combined with power Doppler makes the imaging modalities of choice for early diagnostics and maturity assessment of PTMO.

Abbreviations

AP – alkaline phosphatase
CRP – C-reactive protein
GCS – Glasgow Coma Score
HRUS – High resolution ultrasound
MSCT – Multislice computed tomography
PTMO – Post-traumatic myositis ossificans
TBI – Traumatic brain injury

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