Multiphase contrast-enhanced MRI for control of subacute trauma of abdomen and chest in children

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Purpose

Traumatic damage to abdomen and chest organs in children represents a quite common condition. Such damage occurs as part of associated, combined, multiple and isolated injuries. Sonography and CT are methods of choice for diagnosing acute injuries of parenchymal organs. Computer tomography allows detecting both skeletal and parenchymal lesions. CT diagnostic efficacy can be significantly improved by using multiphase contrast enhancement. This, however, is associated with increased radiation exposure and risk of contrast-induced nephropathy. Thus, single-phase whole-body CT scans (excluding the head) are sometimes obtained 40 or 60 seconds after manual injection of a contrast medium.

Delayed scanning in the subacute phase as well as catamnestic examination of the patient should be performed using a safer method, such as MRI. Multiphase contrast-enhanced MRI is proposed in addition to ultrasound-based dynamic monitoring.
Methods and Materials

24 patients with subacute trauma scored from 9 to 50 on injury severity score (ISS) were examined. Examinations of subacute traumatic injuries in children revealed lesions of parenchymal organs of varying severity: liver (16 cases), kidneys (10), lungs (6), spleen (6) and pancreas (2). Eighteen patients (75%) had multiple injuries.

Examinations were performed using an Achieva 3.0T MRI scanner (Philips, the Netherlands). Before injecting a contrast agent, we used T2-weighted sequences, MRCP, in synchronization with breathing (Navigator method). We used 3D T1-weighted sequence (e-THRIVE) for pre- and postcontrast scans (Gd contrast bolus). The scanning was performed using the breath-hold method, with high spatial resolution (1x1 mm in plane, 1.7 mm slice thickness). e-THRIVE based on 3D T1-TFE (#1-turbo field echo). SPAIR fat-saturation technique was used. TR 3 ms, TE 1,4 ms, FA 10 degree, TFE factor 80, SENSE factor 2. Time acquisition was approx. 15 sec. We injected MR contrast media Magnevist (Bayer, Germany) 0.5 M at a flow rate of 2 ml/sec achieving the final concentration of 0,2 ml/kg. We tracked the bolus by 2D BOLUS TRACK started manually when contrast reached the left ventricle. E-THRIVE scanning was performed within a breath hold (arterial, 30 sec, 1 min, 3 min, 5 min).
Results

In children, acute damage to parenchymal organs is a life-threatening condition occurring as part of associated, combined and isolated injuries. Subacute and long-term complications of injuries may include hematic abscesses, hepatic hematoma, recurrent bleeding, and post-traumatic false aneurisms. Ultrasonography is a method of choice for dynamic monitoring of such patients. However, we propose a different non-invasive method, such as multiphase contrast-enhanced MRI, in order to ensure as detailed evaluation of damage to parenchymal organs as possible. Introduction of new MR technologies with ultrafast scanning methods, such as Philips e-THRIVE technique, has allowed obtaining images with contrast similar to that of multiphase contrast-enhanced MRI, without radiation exposure.

The effectiveness of CT with contrast enhancement in polytrauma demonstrated by several authors (1,2,3).

Below we report a clinical case of a girl N., 10 years of age, presenting with trauma following a 3-metre fall. At admission, the patient underwent enhanced CT following injection of a non-ionic contrast agent in order to assess the extent of damage to the deep parts of the right hepatic lobe, as detected by ultrasonography. This finding was confirmed, as shown on Fig. 1 a, b, moreover, the examination revealed a rupture at the border of the caudate lobe and segment V (Fig. 1 b,c), where a shows the arterial phase, and b, c represent the portal phase.

Multiphase contrast-enhanced MRI was performed 9 days later, confirming the CT findings (see Fig. 1a - the arterial phase, and b, c - the portal phase with a 60-second delay, no negative dynamics. The slices are positioned in the same way as in CT).

Another case is a subject K., 17 years of age, presenting with an isolated chest injury from striking the handlebar when falling. At admission, CT without enhancement revealed pneumothorax, and a contusion/rupture of the left lung parenchyma with a multichamber hemorrhagic cavity (Fig. 2a). CT scanning performed 10 days later showed positive dynamics (Fig. 2b). Another 14 days later, contrast-enhanced MRI was performed using e-THRIVE within a 30-sec breath-hold. The frontal plane (Fig. 2c) shows positive dynamics, such as further regression of the hematoma, recovery of lung tissue airiness, which is clearly visualized based on the pattern of flow through vascular structures. It should be noted that good performance of multiphase contrast-enhanced MRI relies on the contact with the patient as well as the patient's ability to properly execute the instructions to hold their breath.
Also demonstrated the most demonstrative from our point of view, examples there are: arterio-caval fistulae and posttraumatic hepatic pseudo aneurysm (Fig 3), severe combined trauma following a 10-metre fall, ISS 48, hepatic laceration, kidney injuries, retroperitoneal hematoma, pneumothorax, and a contusion of the right lung parenchyma (Fig3), isolated damage to the pancreas (parenchymal laceration with Wirsung duct injury (fig5).
Fig. 1: Patient N., girl, 10 years of age, presenting with trauma occurred following a 3-metre fall. The patient underwent contrast enhanced CT in order to assess the extent of damage to the deep parts of the right hepatic lobe, as detected by ultrasonography (a, b) moreover, the examination revealed a rupture at the border of the caudate lobe and segment V (a - arterial; b,c - portal). Multiphase contrast enhanced MRI using e-THRIVE was performed 9 days later, confirming the CT findings (d - arterial; e,f - portal), no negative dynamics. The slices are positioned in the same way as in CT).

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**Fig. 2:** Patient K, male adolescent, 17 years of age, with an isolated chest injury from striking the handlebar when falling. CT without enhancement revealed pneumothorax, and a contusion/rupture of the left lung parenchyma with a multichamber hemorrhagic cavity (a). CT scanning performed 10 days later showed positive dynamics (b). 14 days later, contrast-enhanced MRI was performed using e-THRIVE within a 30-sec breath-hold (c) shows further positive dynamics.

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**Fig. 3:** Patient N, female adolescent, 15 years of age. After car accident, operated (laparotomy) on for traumatic injuries of the spleen and liver, splenectomy, suture rupture of the liver, surgical treatment of wounds face. 28 days after trauma arterio-caval fistulae and pseudo aneurysm was diagnosed by contrast enhanced CT (a, b and 3D reconstruction c). 3 years later spontaneous fistulae occlusion was detected by multiphase contrast enhanced e-THRIVE MRI (d,e).

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Fig. 4: Patient B male adolescent, 17 years of age with severe combined trauma following a 10-metre fall, ISS 48, hepar laceration damages of the subdiaphragm parts of the right hepatic lobe, kidney injuries, retroperitoneal hematoma, pneumothorax, and a contusion of the right lung parenchyma was detected by MDCT with multiphase contrast injection (a,b,c). Also diffusion axonal injures (type 2), fractures of the pelvis and ribs was detected (not demonstrated). We can observe a very good recovery of the parenchymal organs in the 7 month delayed as shown on (d,e,f), multiphase contrast enhanced e-THRIVE MRI slices at the same location. Stump bandaged additional left renal artery during urgent surgery manipulation (g) and it thrombosis and regress (h).

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Fig. 5: Patient G, boy, 5 years of age, injured when falling from a children's bike: isolated damage to the pancreas (parenchymal laceration with Wirsung duct injury). It was clearly shown on multiphase contrast enhanced MDCT (a,b,c) with giant pseudo cyst formation. CT was performed 17 days after incident. Multiphase contrast enhanced e-THRIVE MRI was performed after 13 days after CT. We can see reducing the volume of the cyst (d,r,f,h), Wirsung duct damage on MRCP scan (g). Catheters as a "pig tail" clearly visualized after the administration of a solution of Gd (i) - pre iv Gd injection T1 WI.

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Conclusion

Multiphase contrast-enhanced MRI represents a method that is being proposed for dynamic monitoring of traumatic damage to parenchymal organs in children. This method has proved effective both in abdomen and chest injuries.
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