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The importance of magnetic resonance arthrography in the diagnosis of shoulder joint instability

Pomen magnetnoresonančne artrografije pri diagnosticiranju nestabilnosti ramenskega sklepa

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Abstract

The shoulder joint is the most mobile joint in the human body due to its structure, but for the same reason, it is also the most unstable joint. With complete or incomplete shoulder dislocations, the joint stabilizers are damaged. That makes the joint even more unstable, which leads to a vicious circle. Shoulder joint instability is often a problem for young people, especially athletes, so an accurate diagnosis of the trauma of small intra-articular structures is crucial for treating shoulder instability. The most established diagnostic method for shoulder instability is MR arthrography under the supervision of fluoroscopy. In recent years, with the rapid development of ultrasound technology, significant progress has been made, especially in the quality of high-frequency linear probes, which allows us to display small soft tissue structures accurately. The latter enabled the development of minimally invasive procedures, especially in the musculoskeletal organ system, in which precision and transparency are indispensable, and which include arthrography.

Izvleček

Ramenski sklep je zaradi svoje zgradbe najbolj gibljivi sklep v človeškem telesu, hkrati pa tudi najbolj nestabilen. Ob popolnih ali nepopolnih izpahih rame pride do poškodbe stabilizatorjev sklepa. To pomeni, da je sklep še dodatno nestabilen, kar vodi v začarani krog. Nestabilnost ramenskega sklepa je pogosto tudi problem mladih, predvsem športnikov, zato je pred zdravljenjem nestabilnosti rame izjemno pomembno natančno diagnosticirati poškodbe drobnih struktur v sklepu. Standardno uveljavljena diagnostična metoda pri nestabilnosti rame je magnetnoresonančna artrografija (MR-artrografija) pod nadzorom fluoroskopije. V zadnjih letih je ob hitrem razvoju ultrazvočne tehnologije prišlo do velikega napredka v kakovosti visokofrekvenčnih linearnih sond, ki nam omogočajo natančen prikaz drobnih mehkotkivnih struktur. Slednje je, zlasti na področju mišično-skeletnega organskega sistema, omogočilo razvoj minimalno invazivnih posegov, pri katerih je natančnost in preglednost še posebno potrebna, mednje pa sodijo tudi artrografije.

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1 Introduction

The shoulder joint is one of the most functionally and structurally complex joints, playing an important biomechanical role in multiple daily activities as it connects the upper limb with the torso. Due to the discrepancy in articular surface size and lax articular capsule, it is both simultaneously the most mobile and least stable joint. Shoulder joint instability is a common clinical problem, manifesting mostly with pain, reduced range of motion and recurrent dislocations of the affected joint (1).

Shoulder instability can occur after an injury. Instability is normally unidirectional, i.e. anterior or posterior. Instability can also be multidirectional, which can be a consequence of congenital structural shoulder joint abnormalities, repeated microtrauma or connective tissue disease (constitutional instability), e.g. in Ehlers–Danlos syndrome or lax connective tissue. The dislocation is in the anterior-inferior direction in 95% of cases, and is typical in falls on an outstretched arm or as a consequence of a direct blow to the shoulder from the posterior side (11). In 3% of cases, the dislocation is posterior, most commonly in young athletes, particularly swimmers, volley ball players, discus or ball throwers and martial arts competitors (3,12). Damaged stabilizers no longer provide optimal support, so these athletes are also more likely to have shoulder joint injuries and sprains later in their careers. Posterior dislocation can also be caused by severe muscle spasms during an epileptic seizure or electric shock (1). Otherwise, dislocations can also be superior, inferior or multidirectional (12).

The diagnosis of shoulder instability is difficult and at the same time extremely important, as it involves damage to small intra-articular structures that significantly contribute to joint stability. Due to their small size and intra-articular location, they are difficult to visualize. The main diagnostic method for an unstable shoulder joint is magnetic resonance (MR) arthrography (13).

2 Magnetic resonance arthrography

MR arthrography is a minimally invasive procedure with high diagnostic reliability, with which we can evaluate intra-articular microtrauma that most commonly occurs in partial or complete shoulder joint dislocations (5). The direct intra-articular injection of a contrast agent distends the joint capsule and separates intra-articular structures that otherwise lie in close contact with each other and are therefore difficult to visualize without contrast (2).

There are two types of arthrography: direct and indirect. In MR arthrography with intra-articular contrast injection the joint capsule is distended, allowing visualization of small intra-articular structures. Therefore, direct arthrography is intended for the evaluation of small intra-articular structures. In the Slovenian healthcare services code list, MR arthrography is listed as MRI of bone, arthrography, each joint: VZS code: 1775.

In MRI with contrast, the contrast agent is injected into a peripheral vein, as the procedure is intended mainly to evaluate structural changes of bone and peri-articular soft tissues. This is needed particularly in case of suspected bone and soft tissue tumours or in inflammatory processes and their complications (abscesses, bone sequestra, etc.).

Arthrography has been used for many years in diagnosing joint pathology. It was introduced in 1933 by Oberholzer, who used air as a negative contrast agent (4,6). Arthrography has gained great importance in the diagnosis of patients with shoulder joint instability with the introduction of water-soluble iodine contrast agents. In 1975, Schneider and colleagues presented a technique with an anterior approach under the control of fluoroscopy, which is still used today (4,7). With the development of ultrasound technology and the growing awareness of the consequences of ionizing radiation, ultrasound-guided arthrography has begun to gain ground in clinical practice in recent years. The main technical and clinical advantages of ultrasound-guided MR arthrography are the ability to examine the joint and surrounding soft tissues before contrast injection, the possibility of following the needle placement in real time; furthermore, an iodine contrast agent is not required and the patient is not exposed to ionizing radiation (18). The main advantage of the posterior over the anterior approach is that it avoids anterior joint structures. These are most commonly damaged in shoulder joint instability, as anterior instability accounts for as much as 95% of all cases. Another advantage is that even when there is extravasation of the contrast it does not obscure the anterior joint structures, which preserves the diagnostic image value.

2.1 Magnetic resonance arthrography approaches

In the standard anteroinferior approach (Schneider technique) we enter the joint at the border between the lower and middle third of the glenohumeral joint. The patient is in the supine position with his shoulder in a neutral position or in external rotation. In the latter, the long head of biceps tendon is displaced laterally in order to gain more space for needle insertion. Under fluoroscopy guidance, the needle position is confirmed with an injection of 1–2 mL of iodine contrast. With the needle in a correct position, 10–12 mL of paramagnetic contrast is injected (13). The standard anteroinferior approach is the most established arthrography technique, but there is a high probability of damage to the anteroinferior structures or stabilizers, such as m. subscapularis, labrum and the inferior glenohumeral ligament (IGHL), which are most commonly damaged in shoulder instability. Therefore, the risk of misinterpretation is much greater (10).

Contrast can also be injected into the joint with an adapted form of the standard anterior technique by targeting the upper half of the joint at the rotator cuff interval (7). This is a triangular space at the superior medial part of the head of the humerus, bounded by the tendons of m. supraspinatus and m. subscapularis, in which the coracohumeral bond and superior glenohumeral ligament (SGHL) are contained, along with the tendon of the long head of biceps muscle (8). The rotator cuff interval is closer to the surface, so the needle's path is shorter. At the same time, external rotation of the shoulder displaces the biceps tendon, which prevents injuries.

Furthermore, physician can also use the posterior approach, in which the patient lies on their unaffected side. Abduction and internal rotation of the affected arm by 90° relaxes the shoulder girdle muscles. The needle is inserted vertically in the inferior-medial quadrant of the upper arm until it hits the cartilage of the proximal humerus (14). The posterior approach is also used in anterior shoulder instability, as it avoids labrum and IGHL injuries; there is also less contrast extravasation. The procedure is also less stressful for patients as they do not see the needle (9).

Ultrasound-guided arthrography, which has become established in recent years, has many advantages. Even before the arthrography, we can examine the joint for effusion. During the procedure itself, we can follow the needle placement in real time. Therefore, needle insertion is easier and safer compared to the fluoroscopy guided approach. An additional advantage is the absence of the radioactive iodine contrast agent (10).

The success rate of contrast administration is almost 100% in all imaging-controlled approaches (fluoroscopy-guided with anterior and posterior approach and ultrasound-guided with anterior and posterior approach). Therefore, the chosen technique should be based primarily on the expected pathology and patient cooperation (10).

Several authors compared fluoroscopy-guided and ultrasound-guided arthrography. A study by Rutten et al evaluated the variability of intra-articular contrast injection success rate, number of contrast injection attempts, extravasation volume and its impact on image interpretation, procedure duration and pain. The study included 100 patients with shoulder joint instability. The first attempt with ultrasound guidance was successful in 94% of subjects, while the first attempt under fluoroscopy guidance was successful in only 72%. They also compared the success of intra-articular contrast injection from the anterior and posterior sides. In the first attempt, 76% of anterior and 68% of posterior arthrographies were successful under fluoroscopy guidance. Under ultrasound guidance, the first attempt was more successful: 96% with the anterior approach and 92% with the posterior approach. They concluded that the first attempt at contrast injection was more successful under ultrasound than under fluoroscopy guidance; ultrasound-guided arthrography is also faster, less painful and does not expose patients to ionizing radiation (15).

In his study, Ji compared the effectiveness of ultrasound-guided anterior and posterior arthrography approaches. The study included 28 patients, which were randomized into anterior (13) and posterior (13) approach groups, while two patients also had, due to severe extravasation during the anterior approach, an arthrography with the posterior approach. In both groups, the success rate was 100%. In the anterior approach group, two patients (15%) had mild and two had severe extravasation, while there were no extravasation events in the posterior approach group; in total, 14% of patients had contrast extravasation. The study results confirmed the safety, effectiveness and relative painlessness of the ultrasound-guided MR arthrography using a posterior approach (17).

The study by Ng et al, which included 40 patients and compared fluoroscopy-guided and ultrasound-guided MR arthrography using the anterior approach, reached similar conclusions. There were 20 patients in each group. The results showed that ultrasound-guided MR arthrography was comparable to fluoroscopy-guided MR arthrography, but with the advantage that the patient and radiologist are not exposed to ionizing radiation (19).

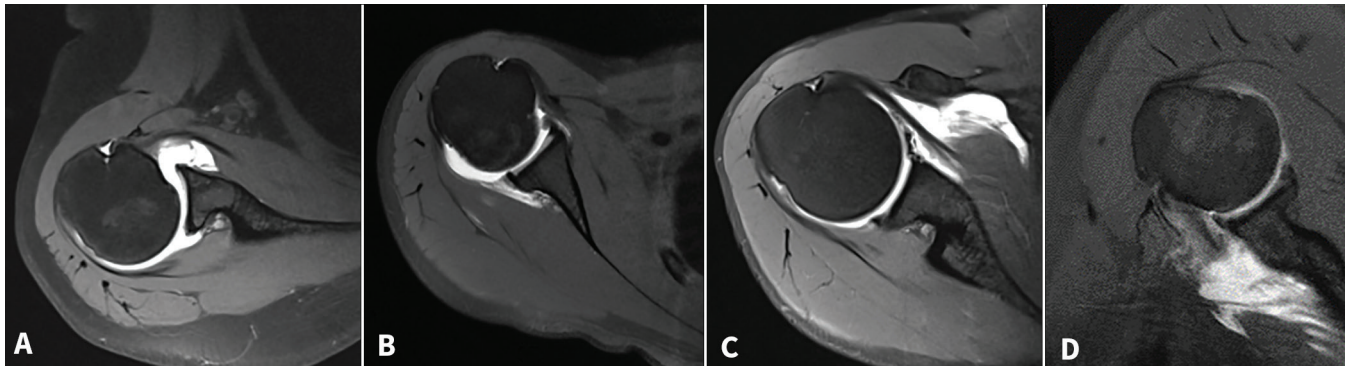

Figure 1: Extravasation was assessed on a four-point scale: 0 – no extravasation (A), mild – along the needle tract (B), moderate – infiltration of the adjacent muscle fascia and muscles (C) and severe – reduced diagnostic value of the test (D). Adapted from Salapura V, et al, 2017 (16).

2.2 Experience at the Institute of Radiology, University Medical Centre Ljubljana

With the introduction of the new method at the University Medical Centre Ljubljana (UMC Ljubljana), the success of ultrasound-guided arthrography was evaluated at the Institute of Radiology. Between April 2015 and April 2016, 67 patients with shoulder joint instability or rotator cuff injury were included in the study of ultrasound-guided MR arthrography using the posterior approach. The purpose of the study was to evaluate the effectiveness and duration of intra-articular contrast agent injection, contrast extravasation volume and rotator diagnosis accuracy after contrast extravasation. We recorded the number of attempts required for successful contrast injection, which we defined as the need for needle repositioning after unsuccessful intra-articular insertion. We measured the injection duration and total procedure duration until the needle was properly positioned. In each patient, the volume of injected contrast was measured, procedural complications were noted and pain assessment was performed (16).

In our study, the first attempt at intra-articular contrast injection was successful in 86.6% of patients; in 11.9%, we needed two attempts, three attempts were needed in only 1.5% of patients. A successful procedure was one where the contrast agent was injected into the joint, which means that in all 67 patients, we were successful on the whole, including in our first attempt. The average duration of contrast injection was 8.8 minutes with an average pain score of 3.6. In 43.3% of patients, contrast extravasation occurred, of which 32.5% were mild, 8.9% moderate and 7.5% severe (Figure 1). Although the proportion appears to be large, most were functionally completely insignificant extravasations that did not interfere with diagnostic procedures. Compared

Table 1: Parameters assessed and comparison with the study by Rutten et al. The first column contains the values from the study at the University Medical Centre Ljubljana, while the 2nd, 3rd and 4th columns contain the values from the study by Rutten et al (15,16).

	USp UMC LJ	USp (15)	USa (15)	FLa (15)
Procedure success rate	100%	100%	100%	100%
Average volume of standard contrast mixture injected	9.8 mL	18.6 mL	14.6 mL	14.5 mL
Extravasation	43.3%	52%	36%	68%
Procedure duration	8.8 min	9.3 min	9.9 min	17 min
Average pain score	3.6	2.7	1.6	3.9
Complications	7.5% (mild)	8%	0%	8%

Legend: UMC LJ – University Medical Centre Ljubljana; USp – ultrasound-guided MR-arthrography using the posterior approach; USa – ultrasound-guided MR-arthrography using the anterior approach; FLa – fluoroscopy-guided MR-arthrography using the anterior approach.

to the anterior approach, the proportion of extravasations is slightly higher, but the posterior approach does not obscure the most frequently injured anterior shoulder joint structures, while the amount of contrast injected into the joint is still suitable for accurate diagnostic assessment (Table 1).

In 7.5% of patients, a mild vasovagal reaction occurred, which all subsided after the patients layed down. No other complications were noted (16).

The study results have confirmed that ultrasound-guided MR arthrography using the posterior approach is a good alternative to fluoroscopy-guided arthrography, but with important advantages for patients (16).

3 Conclusion

MR arthrography is the method of choice for evaluation of small intra-articular shoulder joint structures, which are most commonly injured in shoulder instability.

In addition to the standard minimally invasive arthrography technique, the ultrasound-guided shoulder joint contrast injection technique is now established, as the development of ultrasound technology has made significant progress in the quality of high-frequency linear probes, which allow accurate display of small soft tissue structures. The main advantage of ultrasound-guided posterior approach arthrography is that it avoids the anterior structures that are most commonly injured in shoulder joint instability. At the same time, the method is safe and effective, as it allows examination of the joint before the introduction of contrast and tracking needle placement in real time; additionally, as iodine contrast is not required, the patient is not exposed to radiation.

Conflict of interest

None declared.

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