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IS ANATOMY CLINICALLY IMPORTANT IN SHOULDER SURGERY?

Bartłomiej Kordasiewicz
Shoulder Subunit, Trauma and Orthopaedics Department, SPSK im. A. Grucy, Otwock, Poland
Postgraduate Medical Education Centre, Warsaw, Poland

SUMMARY

Introduction
Arthroscopy has brought some details, especially with reference to glenohumeral joint structures. Within last few years "out of the box" shoulder arthroscopy became more popular. This requires very good anatomic basics and some spatial orientation.

Aim
The goal of this study was to present some aspects of open and arthroscopic shoulder anatomy and their correlation with the clinical practice.

Material and methods
This study was based on the information found on anatomical studies published in 2000–2015 in PubMed database. Additionally 21 fresh cadavers were dissected in Forensic Medicine Department at Warsaw Medical University. This step-by-step dissection allowed to visualize all structures from "out of box" to the glenohumeral joint itself.

Results
Three anatomic areas were presented with special attention to their clinical influence: coracoid process, coracohumeral ligament and glenohumeral joint capsule.

CZY ANATOMIA JEST KLINICZNIE WAŻNA W CHIRURGII BARKU?

Bartłomiej Kordasiewicz
Samodzielny Publiczny Szpital Kliniczny im. Prof. Adama Grucy, Klinika Chirurgii Urazowej Narządu Ruchu i Ortopedii CMKP, Oddział XV (Pododdział Chirurgii Barku), Otwock, Polska

STRESZCZENIE

Wstęp
Artroskopia dostarczyła pewne nowe szczegóły, zwłaszcza w odniesieniu do struktur stawu łopatkowo-ramiennego. W ciągu ostatnich kilku lat artroskopia „poza stawem" stała się bardziej popularna. Posługiwanie się nią wymaga bardzo dobrych podstaw anatomicznych i orientacji przestrzennej.

Cel
Celem tej pracy jest przedstawienie niektórych aspektów otwartej i artroskopowej anatomii barku i ich korelacji z praktyką kliniczną.

Materiał i metody
Badanie to zostało przeprowadzone na podstawie informacji zawartych w badaniach anatomicznych opublikowanych w latach 2000–2015 w bazie PubMed. Dodatkowo dokonano wypreparowanie 21 świeżych zwłok w Zakładzie Medycyny Sądowej Uniwersytetu Medycznego w Warszawie. Sekcje te, wykonane krok po kroku „od zewnątrz" aż do stawu ramienno-łopatkowego, umożliwiły zwizualizowanie wszystkich struktur barku.

Wyniki
Zaprezentowano trzy obszary anatomiczne ze szczególnym uwzględnieniem ich znaczenia klinicznego: wyrostek kruczy, więzadło kruczo-ramienne i torebkę stawu ramienno-łopatkowego.

Conclusions
Results of this study confirmed several important anatomic factors, which should be taken under consideration in clinical practice. It is crucial to know all anatomic relations of the coracoid process. Coracohumeral ligament is one of these structures, spanning into the capsular wall. Subsequently the capsular tissue reinforced with the ligaments stay very tightly related to the rotator cuff tendons. These facts are very important when open or arthroscopic surgery is applied.

Keywords: shoulder anatomy, surgery

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Wnioski
Wyniki tych badań potwierdziły kilka ważnych danych anatomicznych, które powinny być brane pod uwagę w praktyce klinicznej. Bardzo ważne jest, aby znać wszystkie anatomiczne relacje wyrostka kruczego. Więzadło kruczo-ramienne jest jedną z tych struktur, rozciągających się na ścianę torebki. Torba stawowa wzmocniona więzadłami pozostaje w bardzo ścisłym związku z ścięgnami stożka rotatorów. Fakty te są bardzo ważne zarówno podczas operacji „otwartej" i operacji artroskopowych.

Słowa kluczowe: anatomia barku, chirurgia

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Introduction and aim

Shoulder anatomy is relatively well known, having been described for a long time (Clark and Harryman 1992; Curtis *et al.* 2006; Minagawa *et al.* 1998). Arthroscopy has brought some more available details to diagnose and to treat, especially in the glenohumeral joint. Within last few years "out of the box" arthroscopy was used in the space where open surgery was performed routinely so far (Boyle *et al.* 2009). This requires very good anatomic basics and some spatial orientation. The goal of this study is to present some aspects of open and arthroscopic shoulder anatomy and their correlations with clinical practice.

Material and methods

This study is based on the information found on anatomical studies published in 2000–2015 and found on PubMed database. Additionally 21 fresh cadavers were dissected in Forensic Medicine Department at Warsaw Medical University. It was focused on several aspects, very important for clinical practice: rotator cuff anatomy, suprascapular nerve anatomy, coracoid process, latissimus dorsi tendon and proximity of neurovascular structures. For the dissection, the standard deltopectoral surgical approach was performed to achieve the access to the coracoid process. Than the coracoid was liberated from lateral and medial side, and coraco-clavicular ligaments were dissected. Suprascapular nerve was located medially. Than the dissection was followed by coracoid osteotomy distally to the coracohumeral ligament to gain the access to the subscapularis muscle. At this level (slightly medial to the anterior glenoid margin), the subscapularis muscle was cut with maximum external rotation without touching the underlying capsule and labrum attached to the glenoid. Using a saw, the entire anterior glenoid fragment was detached from the scapula leaving the labrum and the capsule attachment was intact. After performing glenoid osteotomy, the proximal humerus was cut from the shaft (2 cm below the subscapularis attachment) along with the remaining soft tissues. Subscapularis blunt dissection was performed to separate the anterior capsule-ligamentous complex (ACLC) and tendon, followed by sharp dissection to the humeral insertion. Analogically similar dissection was performed for the superior and posterior parts of the cuff (Figure 1); this allowed separation of superior and posterior capsule from the cuff tendons. This step by step dissection allowed to visualize all above mentioned areas from "out of box" to the glenohumeral joint itself.

If the pectoralis major tendon is slightly incised at its superior insertion the transverse fibers of the latissimus dorsi tendon are visible just underneath – its superior and inferior border could be easy localized. If these fibers are followed medially, the

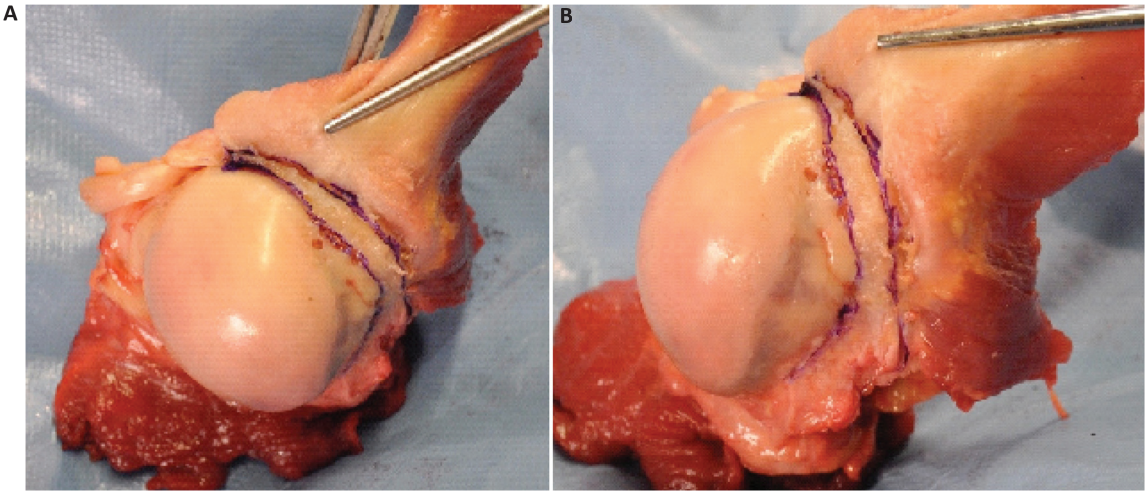

Figure 1. The supraspinatus (A) and infraspinatus with teres minor muscles (B) muscle and underlying anterior capsule-ligamentous complex were dissected – superior and posterior capsule was excised, footprint of the capsule was marked and rotator cuff tendons with muscles are reflected.

radial nerve could be visualized. Going backwards to the subscapularis, under and medially to the coracoid muscle, important neurovascular structures can be found: axillary nerve, 3–5 small branches to the subscapularis muscle, and brachial artery with brachial plexus. Brachial plexus could be also visualized from above and medially to the coracoid. It is possible to visualize the plexus and artery above the pectoralis minor tendon. This could be easier if the pectoralis minor tendon is released from the lateral border of the coracoid. This enables further dissection of the plexus – the most anterior one is a musculocutaneus nerve penetrating the condoined tendon. If the lateral border of the coracoid is followed the coracoclavicular ligaments are to be found: trapezoid and conoid. Slightly medial to conoid ligament the suprascapular nerve is passing under transverse scapular ligament. All these structures are important in clinical activity – it is important to remember the area lateral to the coracoid is relatively safe.

Results and discussion

Three anatomic areas are presented with special attention to their clinical influence: coracoid process, coracohumeral ligament and glenohumeral joint capsule.

Coracoid process

Coracoid process is the crucial structure in "out of box surgery" (Boyle *et al.* 2009). A guide to coracoid in subacromial space is the coracoacromial ligament (CAL). It is easy to follow the lateral border of the CAL to find a lateral-distal border of the coracoid. Following it distally, the conjoined tendon could be found. Laterally and distally to the conjoined tendon, after dissection of the clavi-pectoral fascia, the superior border of the pectoralis major could be found, passing over the long head of the biceps. At this level, more dorsally to the conjoined tendon an anterior surface of the subscapularis muscle is situated. Three sisters – 2 anterior circumflex veins and arteries are visible at its inferior border.

The medial zone is not very dangerous as long as the surgeon is aware of the presence of all important structures and can visualize it. If not, this could be a real "suicide area" which should be avoided in the first steps of less experienced surgeons.

The special attention should be performed whilst surgery around coracoid and retractors placement: Latarjet procedure, coracoclavicular ligament recostruction, subscapularis repair and latissimus dorsi tendon transfer (Latarjet 1954; Lafosse *et al.* 2005; Lanz *et al.* 2013; Jermolajevas and Kordasiewicz 2015). These procedures require a clear dissection and visualisation of the coracoid at the starting point. The possibility of brachial plexus dissection above the coracoid and further above the clavicle was already proven, but its clinical importance is not very clear yet (Lafosse *et al.* 2015). It is believed to resolve some postraumatic brachial plexus symptoms or some forms of the thoracic outlet syndrome.

Coracohumeral ligament

The coracohumeral ligament (CHL) was classically described to originate in the outer margin of the horizontal limb of the coracoid process and inserted into the greater and lesser tuberosities (Clark and Harryman 1992). It covers the rotator interval – the space between the supraspinatus and subscapularis muscles. The posterior extension of the CHL from the rotator interval has become well known since the anatomic study of Clark and Harryman who showed that CHL constituted the superficial and deep branches of the CHL (1992). This envelope fans out laterally and posteriorly over the supraspinatus reaching the infraspinatus tendon and merges with the periosteum of the greater tubercle (De Palma 1950). Harryman *et al.* (1992) reported that the CHL divides into two major bands, one of which inserts into the tendinous anterior edge of the supraspinatus and the other of which inserts into the superior border of the subscapularis. Nimura *et al.* (2012) in the anatomic study on cadavers stated that CHL could be divided into two parts: one spreading its fibers over the rotator interval to the posterior portion of the greater tubercle and the other part extending its fibers to envelop the cranial part of the subscapularis muscle. In other words the superficial layer of the anterior part of CHL seamlessly continues to the subscapularis fascia and tightly covers the anterior surface of this muscle. Consequently, this part of CHL envelopes the whole subscapularis insertion including the tendinous slip. The CHL is stained immunohistologically more densely for type III collagen than the subscapularis or the long head of the biceps tendon. Type III collagen is more pliable than type I collagen (Franchi *et al.* 2007). It means that the CHL should be relatively flexible. It explains why the CHL can envelop the subscapularis muscle while maintaining the position of the insertion pressed against the humeral head (Nimura *et al.* 2012). Nimura *et al.* (2012) conclusion was that CHL holds the rotator cuff muscles and anchors them to the coracoid process: anterior part – the subscapularis muscle, posterior part – the supraspinatus. This conclusion suggests the CHL plays a major role in the stabilization of the subscapularis, supraspinatus and infraspinatus muscle. This statement has its clinical implication: in case of the subscapularis rupture a scar tissue formation in the CHL as well as adhesion with surrounding structures. This is the reason why patients benefit from CHL removal – this liberates the tendon and muscle that allows proper restoration of the mobility and fixation.

Capsule relation with rotator cuff tendon

Glenohumeral joint capsule stays in close relations with surrounding rotator cuff tendons and muscle (Boyle *et al.* 2009). As it was already discussed above, the rotator cuff muscles are enveloped with coracohumeral ligament fibers (Clark and Harrzman 1992; Nimura *et al.* 2012). These fibers reinforce the capsule, which is in a very tight relation with the tendons at their humeral insertion. This was already proven by Nimura *et al.* (2012) and Pouliart *et al.* (2007), who dissected precisely the ligamentous structures of the capsule. Nimura *et al.* (2012) measured the width of the attachment of the capsule and tendon on the greater tuberosity. The maximum capsular width (9.1mm) was located at the border between the infraspinatus and the teres minor. The minimum capsular width was 3.5 mm and it was located at 11 mm posterior to the anterior margin of the greater tuberosity. The attachment of the articular capsule of the shoulder joint occupied a substantial area of the greater tuberosity. In particular, at the border between the infraspinatus and the teres minor, the very thick attachment of the articular capsule compensated for the lack of attachment of muscular components (Nimura *et al.* 2012). Own anatomical study about subscapularis footprint has shown the similar relation between subscapularis tendon and underlaying capsule (Figure 1). The subscapularis muscle and the middle and anterior bundle of the glenohumeral ligaments form the anterior wall of the shoulder joint. The medial glenohumeral ligament (MGHL) and the anterior bundle of the inferior glenohumeral ligament (ABIGHL) are in very close proximity to the subscapularis muscle and tendon. At their insertion onto the lesser tuberosity all these structures were fused but their fibers stayed separated. Whilst arthroscopy or open surgery the exact localization of the ligamentous structures is not always obvious due to an anatomical variation, “fluent” limits between ligaments and its intracapsular run. For this reason, we have decided to describe the anterior capsule and its ligaments (MGHL and ABIGHL) as a single structure: the anterior capsulo-ligamentous complex (ACLC). In our anatomic study it was clear to identify subscapularis muscle with its tendinous chords and the anterior capsule-ligamentous complex (ACLC), forming together the anterior wall of the joint. The ACLC insertion complemented the tendon insertion – superiorly the thickest part of the tendon stayed in contact with the thinnest part of the ACLC and inferiorly the relation was opposite – the ACLC insertion reached its maximum transverse length. This reciprocal relation was similar to superior and posterior rotator cuff tendon-capsule complex described by Nimura *et al.* (2012). The footprint on the lesser tuberosity was composed in 45% of the ACLC insertion. Pouliart *et al.* (2007) presented the anatomic study confirming the presence of two layers of the rotator cuff: static one – capsule-ligamentous complex and dynamic one – rotator cuff tendon. In their anatomic dissection there were shown some variants of superior capsule-ligamentous complex, composed constantly with the coracohumeral, coracoglenoid, and superior glenohumeral ligaments joined with a circular transverse band to form the anterior limb of a suspension sling. It was also proved, that in 90% of the specimens, there also was a posterior limb of this complex – posterosuperior glenohumeral ligament joining posterolaterally with the circular transverse band (2012). Czyrny (2012) confirmed this 2 layer structure in his ultrasound and MRI-study. Superior as well as anterior-inferior complex can be depicted by both US and MRIas separate from supraspinatus, infraspinatus and subscapularis tendon layers of tissue with different fiber orientation in dynamic US inspection. It allows to describe the rotator cuff as a multilayer structure consisting of fused fibers of tendons and capsuloligamentous complex. The thickness of these layers is comparable, therefore it is important to realize, that capsular pathologies may become a serious reason for problems of normal shoulder function.

The above phenomenon has several clinical implications. Czyrny (2012) reported his concept in rotator cuff calcification formation; he stated that the enthesis fibrocartilage and underlying cortex are destroyed at the level of the border between static and dynamic layer of the cuff. This zone of injury could become a source of calcium deposits. It explains why in most of the cases calcifications are located between tendon and capsuloligamentous complex.

In cases of the rotator cuff tear, the static – ligamentous part of the rotator cuff becomes retracted. If it is not released (together with CHL), the rotator cuff retraction can make these tendons impossible to liberate and to reinsert onto their anatomic attachment. It clearly explains the necessity to perform intra- and extraarticular tendons release as a first step of rotator cuff reconstruction.

In a frozen shoulder, the thickness and stiffness of the capsule (with coracohumeral ligaments playing the main role) are responsible for loss of mobility in the glenohumeral joint. The restoration of the regular elastic structure of the capsule brings a shoulder mobility to normal.

In arthroscopic Latarjet stabilization, most of the surgeons excise the anterior capsule-ligamentous structures to visualize and then split the subscapularis muscle. This step is safe, as the capsule is a separate layer that can be taken out without harming the subscapularis.

Conclusion

Results presented in this paper confirm several important anatomic factors, which should be taken under consideration in a clinical practice. It is crucial to know all anatomic relations of the coracoid process. The coracoid process is used to be named "a light house" for shoulder surgery. Lots of important structures are linked with it. They play the crucial role in a safety of the procedure as well as in the clinical result. The coracohumeral ligament is one of these structures, spanning into the capsular wall. It is very important to be aware of this, and to be able to find and release this structures whilst open or arthroscopic surgery.

REFERENCES

Boyle S., Haag M., Limb D., Lafosse L. *Shoulder arthroscopy, anatomy and variants – part 2*. Orthopaedics and Trauma 2009; 23, 5: 365–376.

Clark J.M., Harryman D.T. *Tendons, ligaments, and capsule of the rotator cuff. Gross and microscopic anatomy*. The Journal of Bone and Joint Surgery. American Volume 1992;74: 713–725.

Curtis A.S., Burbank K.M., Tierney J.J., Scheller A.D., Curran A.R. *The insertional footprint of the rotator cuff: an anatomic study*. Arthroscopy 2006; 22: 609.e1.

Czyrny Z. *Diagnostic anatomy and diagnosticsof enthesal pathologies of the rotator cuff*. Journal of Ultrasonography 2012; 12: 178–187.

DePalma A.F. *Coracohumeral ligament. Surgery of the shoulder*. Philadelphia, J.B. Lippincott, 1950.

Franchi M., Trire A., Quaranta M., Orsini E., Ottani V. *Collagen structure of tendon relates to function*. The Scientific World Journal 2007; 7: 404–420.

Harryman D.T., Sidles J., Harris S.L., Matsen F.A. *The role of the rotator interval capsule in passive motion and stability of the shoulder*. The Journal of bone and joint surgery. American volume 1992; 74: 53–66.

Jermolajevas V., Kordasiewicz B. *Arthroscopically assisted latissimus dorsi tendon transfer in beach-chair position*. Arthroscopy Techniques 2015; 10, 4, 4: e359–63.

Lafosse L., Baier G.P., Leuzinger J. *Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation*. Arthroscopy 2005; 21, 8: 1017.

Lafosse L., Lejeune E., Bouchard A., Kakuda C., Gobezie R., Kochhar T. *The arthroscopic Latarjet procedure for the treatment of anterior shoulder instability*. Arthroscopy 2007; 23, 11: 1242.e1–5.

Lafosse T., Masmejean E., Bihel T., Lafosse L. *Brachial plexus endoscopic dissection and correlation with open dissect*ion. Chirurgie de la Main 2015; 34, 6: 286–293.

Lanz U., Fullick R., Bongiorno V., Saintmard B., Campens C., Lafosse L. *Arthroscopic repair of large subscapularis tendon tears: 2- to 4-year clinical and radiographic outcomes*. Arthroscopy 2013; 29, 9: 1471–1478.

Latarjet M. *A propos du traitement des luxations recidivante de l'epaul*e. Lyon Chir 1954; 49: 994–1003.

Minagawa H., Itoi E., Konno N., Kido T., Sano A., Urayama M., Sato K. *Humeral attachment of the supraspinatus and infraspinatus tendons: an anatomic study*. Arthroscopy 1998; 14: 302–306.

Nimura A., Kato A., Yamaguchi K., Mochizuki T., Okawa A., Sugaya H., Akita K. *The superior capsule of the shoulder joint complements the insertion of the rotator cuff*. Journal of Shoulder and Elbow Surgery 2012; 21: 867–872.

Pouliart N., Somers K., Eid S., Gagey O. *Variations in the superior capsuloligamentous complex and description of a new ligament*. Journal of Shoulder and Elbow Surgery 2007;16: 821–836.

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Author responsible for correspondence:
Bartłomiej Kordasiewicz
Shoulder Subunit, Trauma and Orthopaedics Department
SPSK im. A. Grucy
Konarskiego 13
05-400 Otwock, Poland
kl.chir.ur@spskgruca.pl

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Autor odpowiedzialny za korespondencję:
Bartłomiej Kordasiewicz
Samodzielny Publiczny Szpital Kliniczny im. Prof. Adama Grucy
Klinika Chirurgii Urazowej Narządu Ruchu i Ortopedii CMKP
Oddział XV (Pododdział Chirurgii Barku)
ul. Konarskiego 13
05-400 Otwock, Polska
kl.chir.ur@spskgruca.pl