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Proximal humeral fractures in elderly patients

Złamania końca bliższego kości ramiennej u osób starszych

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S u m m a r y

Proximal humeral fractures (PHFs) constitute about 5% of all fractures and its' frequency increase with age. There is no one applicable classification of these fractures. The evaluation of the type of the fracture and the degree of displacement of the bone segments is crucial in therapeutical decision making. There are no unambiguous indications for operative treatment and the biggest controversies stir up 3- and 4-part fractures. The Neer's classification is the mostly common used one. The majority of PHFs are type intra-articular and so anatomical reduction is required. Common complication of considered trauma is humeral head ischemia. Failure in reducing the greater tuberosity of humerus leads to poor outcomes with no good salvage options. It is essential to observe the principles of stable osteosynthesis. Anatomical and stable fixation of the fracture must ensure the possibility of immediate passive rehabilitation of the shoulder. Lack of adequate postoperative rehabilitation may result in posttraumatic "frozen shoulder". Surgical management of these fractures in younger patient is challenging because in that group there is lesser tolerance of dislocation. Fractures of the chirurgical neck of the humerus are considered to be extra-articular fractures and are mostly treated conservatively. Considering 3- and 4-part fractures sometimes the only reasonable way of proceeding is humeral hemiarthroplasty. Nevertheless it is vital to emphasise that nowadays there is no clear algorithms of treatment proximal humeral fractures.

Key words: proximal humeral fractures, humeral hemiarthroplasty, stable osteosynthesis, Neer's classification

S t r e s z c z e n i e

Szacuje się, że złamania końca bliższego kości ramiennej stanowią ok. 5% wszystkich złamań, a ich częstość występowania wzrasta z wiekiem chorych. Żaden obecnie stosowany system klasyfikacji złamań tej okolicy nie jest doskonały. Ocena typu złamania oraz stopnia przemieszczenia odłamów jest kluczowa w podjęciu decyzji terapeutycznej. Nie istnieją jednoznaczne wskazania do leczenia operacyjnego, zaś największe kontrowersje budzą złamania 3- i 4-fragmentowe. Najczęstszym stosowanym kryterium do oceny złamań jest klasyfikacja Neera. Większość złamań tej okolicy można traktować jako uszkodzenia stawowe, a więc wymagające leczenia „anatomicznego". Złamania końca bliższego kości ramiennej mogą być powikłane martwicą kości ramiennej. Inną cechą tych złamań jest kluczowa funkcja guzka większego kości ramiennej. W przypadku podjęcia decyzji o leczeniu operacyjnym konieczne jest stosowanie się do zasad stabilnej osteosyntezy. Anatomiczne, stabilne zespolenie musi zapewniać możliwość natychmiastowej biernej rehabilitacji barku. Brak odpowiedniej rehabilitacji pooperacyjnej niesie ze sobą ryzyko rozwoju pourazowego „barku zamrożonego". W przypadku złamań u młodych chorych tolerancja dopuszczalnego przemieszczenia odłamów jest bardziej ograniczona. Złamania szyjki chirurgicznej jako złamania pozastawowe mogą być w znacznej większości leczone nieoperacyjnie. Leczenie złamań 3- i 4-fragmentowych niekiedy wymaga zastosowania endoprotezoplastyki połowiczej barku. Istotne jest podkreślenie faktu, że na dzień dzisiejszy brak jest jednoznacznych wskazań i algorytmów postępowania w przypadku omawianych złamań.

Słowa kluczowe: złamanie końca bliższego kości ramiennej, endoprotezoplastyka połowicza barku, stabilna osteosynteza, klasyfikacja Neera

EPIDEMIOLOGY

Proximal humeral fractures account for ca. 5% of all fractures (1) and they are the second most common fractures in the upper limb, following proximal radial fractures, but in patients over 65 years of age, they are the third most common fracture following proximal femoral fractures and proximal radial fractures (2). Palvanen recorded a threefold increase in number of these fractures between 1970 and 2002 (3). The incidence of these fractures is significantly higher

in females (proportion of males to females – 3:7), and other risk factors include low quality of the bones and risk of fall (4). 3- and 4-part fractures account for 15% of all fractures (5). It is believed that approximately 70% of 3- and 4-part fractures of the proximal humerus occur in patients over 60 years of age, including 50% in patients over 70 years of age (6).

CLASSIFICATIONS AND INDICATIONS FOR SURGICAL TREATMENT

There are many classification systems of proximal humeral fractures, and the most common are: Neer, AO, Codman-Hertel and an additional Resch system (7-11). Evaluation is made based on X-ray images in 2 projections (AP and Y-gamma) and computerized tomography (usually with 3D reconstruction). According to Neer (7), determining factors in fracture classification include presence of displacement and the number of fragments: group I – undisplaced, group II, III and IV: 2-, 3- and 4-part fractures, respectively; in total, there are 16 types of fractures. This is the most commonly used classification. According to AO, type A includes extra-articular, two-part (unifocal) fractures, type B includes extra-articular, three-part (bifocal) fractures, and type C includes articular fractures. These groups are further divided into the subtypes depending on displacement and degree of crush of the bone fragments, giving 27 types of fractures in total (8). The Resch classification describes the type of displacement and the pathomechanism of the fracture. A key issue is to differentiate whether the fracture belongs to the "impaction" type (unchanged position of the greater tubercle, with rotation of the humeral head and maintained total length of the humerus) or "disruption" type (increased distance between the greater tubercle and the shaft or the head and the shaft). Then, it is necessary to establish whether the fracture is a varus type, a valgus type or a neutral type, depending on the angle within the frontal plane at the image in AP projection. In the scapular plane projection, it is possible to evaluate the flexion, extension or neutral nature of the fracture (11). The unanimity of independent investigators regarding evaluation of the fracture type still remains low, which means that none of the currently used systems is perfect (12-14). According to Resch, the Codman-Hertel system, also referred as the "Lego bricks" system and the additional description of his authorship, is currently the best system for classifying proximal humeral fractures, which also evaluates the condition of the so-called medial hinge, as a support of the humeral head (9-11) and the length of the "metaphyseal" fragment accompanying a detached humeral head (9, 11). Among 200 multifragmentary fractures, 43% constituted fractures of a "varus" type, 31% – fractures of a "valgus" type, and 25% – fractures with the accepted position of the bone fragments (i.e. below 20 degrees of displacement). Among fractures of a "varus" type, 25% constituted fractures of a "disruption" type and 18% constituted an "impaction" type (11). Evaluation of this type of fracture and the degree of displacement of the bone fragments constitutes a base for qualification of the patients for surgical or non-surgical treatment. There are no explicit indications for surgical treatment, but the most controversial are 3- and 4-part fractures, which are the leading subject of this article, because they mainly occur in elderly patients. The most frequently used criterion for evaluation of fractures is Neer's classification, which defines the following indications for surgical treatment: displacement exceeding 1 cm including the head and the shaft, displacement of the humeral tubercles, and angular position exceeding 45 degrees (7). These criteria will be discussed in the further part of this article.

SPECIFICITY OF PROXIMAL HUMERAL FRACTURES

Proximal humeral fractures are characterized by a few characteristics. The fractures are located in 2 regions comprising the shoulder – the glonohumeral joint, and the subacromial space, which may significantly influence its biomechanics (15, 16). Therefore, a majority of fractures in this area may be treated as articular injuries, so they require "anatomical" reposition – conservative or surgical (compliant with the rules of stabile osteosynthesis of the intra-articular fractures, see below) (8). This process involves an accurate evaluation of the bone fragments, i.e. suitable X-ray diagnostics (RTG, CT). Specific vascularization of this area is also important (9). Due to this fact, proximal humeral fractures may be complicated with necrosis of the humerus, despite the correct treatment. According to Boileau, the risk of necrosis occurrence is different depending on the fracture type:

- 2-part fractures with displacement – < 10%,
- 3-part fractures with displacement – 1-25%,
- 4-part fractures valgus impacted – 25-30%,
- 4-part fractures with displacement – 40-60%,
- 4-part fractures with dislocation – 80-100% (17).

According to Hertel, the most important risk factors of post-traumatic necrosis of the humeral head is the length of the "metaphyseal" fragment accompanying the detached humeral head ("calcar segment" < 8 mm), the break of the medial arch between the shaft and the head of the humerus ("medial hinge disruption" > 2 mm) and type of the fracture in the "LEGO" classification. Most frequently it refers to the fractures including anatomical head fractures, such as:

- isolated two-part fracture of the humeral neck – type 2,
- 3-part fracture with detachment of the head and the greater tubercle, the shaft remains with the lesser tubercle – type 9,
- 3-part fracture with detachment of the head and the lesser tubercle, the shaft remains with the greater tubercle – type 10,
- 3-part fracture with detachment of the head, the greater and the lesser tubercle are attached to

each other, but detached from the shaft and the head – type 11,
– 4-part fracture with detachment of the head at the level of the anatomical head – type 12.

According to the same author, the degree of displacement of the bone fragments was less significant, similarly to the presence of the dislocation (9). Despite significant attention that is paid to the vascularization (i.e. vitality) of the humeral head, it should be remembered that necrosis may be well-tolerated by the patients over many years (18). Due to the incidence of these fractures in elderly patients, an important factor is the condition of the bones, with special considerations of the quality of the humeral head, the degree of "crush" of the humeral tubercles and the thickness of the cortical bone in the shaft (it is believed that for standard internal osteosynthesis, a cortical layer of at least 4 mm thick is required) (17, 19).

The next special characteristic of proximal humeral fractures is the key function of the greater tubercle of the humerus. The greater tubercle is the main "indicator" of the correct reposition of the humeral head (or the endoprosthesis head). Correct reposition of the greater tubercle ensures not only the possibility to "support" the humeral head, but also to provide correct vascularization. Moreover, due to anatomical attachments of tendons of the rotator cuff to the greater tuberosity (including two external rotators), its incorrect reposition corresponds to massive damage of the rotator cuff (17, 20).

PRINCIPLES OF NON-SURGICAL TREATMENT

While making a decision on non-surgical treatment, it is necessary to consider the following factors:

1. **Characteristics of the fracture: type and displacement.** According to Neer, displaced fractures that are qualified for surgical treatment, include fractures with displacement exceeding 1 cm or in angular position of approximately 45 degrees (21). According to Solberg, an angular displacement of the head exceeding 20 degrees may be sufficient indication for surgical treatment (22, 23). In the case of displacement of the tubercles, these criteria are more rigorous, but in elderly patients, the limit of approximately 1 cm seems to be a standard (a detailed description of the management in the case of humeral tubercles is presented in the further part of the text).
2. **Risk factors on the patient's side:** age, general condition, life requirements, rehabilitation potential.
3. **Risk factors on the surgeon's side:** skills, diagnostic and surgical abilities, implant availability etc.

Non-surgical treatment includes immobilization of the limb in a bandage, which enables performing hygienic procedures and passive rehabilitation of the shoulder after recession of pain. The patient is immobilized and cannot perform any active movement over the period of 6 weeks. Over this time, passive rehabilitation of the shoulder begins – swinging moves; it is also necessary to maintain mobility of other areas of the upper limb – the scapular wall slide, normal mobility of the elbow joint, the wrist and fingers. According to Boileau, the best method of patient immobilization should be bandage with the upper limb rotation in a neutral position (not, as usually used, in a Dessaulte position – adduction and internal rotation – "hand placed on the abdomen") (17). Neutral position in the bandage ensures decrease in forces pulling the greater tubercle (i.e. decreasing the risk of displacement), and in the case of humeral neck fractures, it prevents fusion in the excessive internal rotation of the shaft (nearly 90 degrees) (17).

CONDITIONS OF SURGICAL TREATMENT

In the case of decision on surgical treatment, it is necessary to observe the rules of stable osteosynthesis (8). Anatomical, stable fusion has to ensure the possibility of instant passive rehabilitation of the shoulder. If the mobility of the joint is not ensured, it is a serious risk of development of posttraumatic "frozen shoulder" (17, 24).

TWO-PART SHOULDER

Fractures of the greater tubercle

Isolated fractures of the greater tubercle constitute approximately 2% of surgically treated fractures. Fractures of the greater tubercle are relatively rare fractures in elderly patients. They occur much more often in middle-aged patients, in approximately 15-30% cases may occur as damage accompanying anterior displacement of the shoulder, but in these cases, development of instability is rare (25-27).

Indications for surgical treatment include displacement of the greater tubercle exceeding 0.5-1 cm. In young patients with over head activity this limit is even more restrictive and is shifted to 3mm, whereas in elderly patients tolerated displacement is enlarged to ca. 1 cm (28). Some authors believe that even in the case of undisplaced or insignificantly displaced fractures of the greater tubercle, intra-articular damage occurs – mainly in reference to the deep layer of the tendons of the rotator cuff, which may lead to permanent complaints and limitation in the patients' capabilities (29).

Fixation of the greater tubercle fracture may take place with an open or an arthroscopic method, but the latter method is slightly more demanding from the technical point of view. Usually, the cortical screws (frequently cannulated ones) with washers (in order to obtain even distribution of forces, in order to avoid fracture of the greater tubercle) are used in fixation as well as sutures with systems of "double-row" fixation of the rotator cuff (30-32).

FRACTURES OF THE LESSER TUBERCLE OF THE HUMERUS

Isolated fractures of the lesser tubercle are rare fractures, relatively poorly documented in the literature. The incidence of these fractures was established in one

of the studies at the level of 0.46 per 100 000 patients per year (33). In the case of fractures of the lesser tubercle, surgical treatment dominates, but there are no clear criteria defining indications. This situation probably results from the fact that the lesser tubercle is the peripheral attachment of the tendon of the subscapularis muscle, which constitutes approximately 50% of the strength of the rotator cuff (34). Failure of this muscle related to damage of the tendon attachment may cause a significant dysfunction of the shoulder. Due to this fact, conservative treatment is rather indicated in cases of undisplaced fractures, stable in X-ray and ultrasound evaluation. Unstable fractures rather require surgical treatment, which similarly to fractures of the lesser tubercle, may take place using the open or arthroscopic method (33, 35). However, in case of the lesser tubercle, it seems that the arthroscopic method is significantly less invasive, and at the same time it provides better precision for release and fixation of the fracture (36).

SURGICAL NECK FRACTURES

A vast majority of surgical neck fractures (80%), as extra-articular fractures, may be treated with non-surgical methods (37). If the decision on surgical treatment is made, the most frequently used methods include fixation with a plate (in the majority of cases, with angular stable plates – in this case, locking screws are placed on the plate) or fixation with an intramedullary nail. Depending on the fracture type (the length of the fissure, the level of damage etc.), this fixation may be reinforced by the loops around the bone, which increase stability and compression of the bone fragments (8).

MULTIFRAGMENTARY FRACTURES

In 3- and 4-part fractures, it is crucial to perform evaluation according to the aforementioned criteria. According to Solberg, angular displacement of the head should not exceed 20 degrees. If the decision on surgical treatment has been made, the following management methods are available:

1. Osteosynthesis, with low risk of necrosis and good quality of the bone.
2. Osteosynthesis, with significant risk of necrosis – attempt to treat with maintained "own" humeral head, especially in young patients, with possible implantation of endoprosthesis in the second stage of treatment, in case of poorly tolerated necrosis of the humeral head, but normally healed humeral tubercle.
3. Shoulder hemiarthroplasty, in case of significant risk of the necrosis development and low potential of healing (age, bone quality, fracture type).

OSTEOSYNTHESIS

In 3- and 4-part fractures, there is the possibility to use open fixation with the plate, or minimally invasive method with intramedullary nail or pecutaneous fixation with cannulated screws (in the past, with K-wires), as an isolated technique or modified with the "Humerusblock" system (11, 38).

Fixation with a plate (usually with an angular stability) enables fixation of the head to the shaft of the humerus, frequently with use of bone implants, in order to achieve support for the head (4, 22, 23, 39, 40).

As it was mentioned before, the key role is played by reposition of the greater tubercle of the humerus. There are some fractures that require stabilization of the tubercles with sutures or additional fixation with the screws. The key issue is to perform the fixation correctly from the technical point of view in order to avoid penetration of the screws through the humeral head (during surgery or in later period, in the case of development of the head necrosis). Disadvantages of fixation with a plate include relatively massive opening of the fracture and skeletonising of the bone fragments, which may be another crucial factor of development of the necrosis of the humeral head. Furthermore, massive opening causes creating cicatrix within the subacromial space, which may impede recovery of the shoulder to its complete mobility. The outcome is better in young patients, and treatment does not exclude complications (41). According to Thanasas (based on literature), incidence of complications is 7.9% in the case of development of the humeral head necrosis and 11.6% in the case of penetration of the screws beyond the humeral head, and frequency of repeated surgery is 13.7%. The prospective study in elderly patients demonstrated better outcome in patients after fixation with the plate comparing to non-surgical treatment (but without statistical significance). However, in the group of surgically treated patients, 30% revealed the necessity of repeated surgery: in 13% due to significant problems (infection, hematoma, lack of union and symptomatic necrosis), in 17% due to "smaller complications" (removal of the fixation and releasing the "frozen shoulder") (42).

Until recently, fixation with the intramedullary nail in multifragmentary fractures had a bad reputation (43). Usually, it resulted from the incorrect position of the head in reference to the shaft and lack of stable osteosynthesis of the humeral tubercles. There were also reports on problems with the locking screws (44). However, recently some articles have been published about the new types of intramedullary nails (17). These nails are straight (they do not damage the area of the attachments of the rotator cuff and the greater tubercle), and locking screws are placed in the angular position, which facilitates osteosynthesis of the tubercles. In the case of intramedullary nails, a significant advantage is their minimal invasiveness, as well as low blood loss. However, this procedure is relatively difficult from the technical point of view, because percutaneous reposition and fixation of not only the head, but mainly the humeral tubercles are the key factors for the success. Similarly, the fracture fixation with the "Humerusblock" system is a promising procedure, but it is relatively demanding from the technical point of view. It is a combination of fixation with cannulated screws (reposition of the tubercles) and stabilization of the head to the shaft using 2 K-wires fixed in the head, placed steeply

along the medial cortical layer of the humeral neck and locked peripherally in the cylindrical system fixed in the shaft of the humerus. Fixation with cannulated screws ensures anatomical position of the bone fragments (however, it is technically demanding), but fixation with K-wires along the axis of forces acting on the fractures allows a natural placement of the head ("sintering effect") on the shaft of the humerus (45, 46).

SHOULDER ARTHROPLASTY

In the case of fractures in which osteosynthesis is burdened with a high risk of failure, shoulder hemiarthroplasty should be considered. Currently, there are no publications presenting successful repetition of the promising conditions presented by Neer (7, 47). Arthroplasty in the proximal humeral fractures belongs to the most difficult surgeries of this region, and its outcome is not fully predictable (48). Similarly, as it is in case of osteosynthesis, one of the factors deciding on the final outcome is the correct reposition and fixation of the greater tubercle. Therefore, the technique of fixation of the tubercles is very important, because it provides a chance of healing for these structures around the endoprosthesis head. Usually reinforced sutures are used, and 4 sutures around the tubercles and endoprosthesis are placed as well as 2 sutures connecting the tubercles to the shaft of the humerus (49). The prospective study by Olerud comparing hemiarthroplasty to non-surgical treatment in 4-part fractures revealed a better outcome after implantation of the endoprosthesis, not only in terms of pain evaluation, but also in the quality of life evaluation (42). No significant differences in reference to movement were established. Repeated surgery was necessary only in 2 patients after shoulder hemiarthroplasty – due to "frozen shoulder" (arthroscopic arthrolysis) and lack of union of the greater tubercle. There are some reports on using reversed endoprosthesis instead of hemi-endoprosthesis, but there are no publications showing their superiority (50-52). Considering the facts that the imlantation of the reversed endoprosthesis is technically demanding, the condition of the axillary nerve after the fracture is often not easy to evaluate and economic aspects as well (cost of the prosthesis), it does not seem that reversed arthroplasty would be the routine procedure in the fractures.

SUMMARY

The article above generally considered the basic methods of fixation of proximal humeral fractures. Problem of fractures occurring in this region will be more and more frequent due to the aging process of the population. At the same time, there are no unambiguous indications and management algorithms. The development of highly specific guidelines will probably never be possible, but systematizing the management of patients seems to be highly desirable. The literature is not unanimous; a given method of treatment is supported by some reports or rejected by other ones. In reference to the aforementioned, it seems to be necessary to perform prospective, multicenter studies based on a carefully prepared database of patients. The next step is the development of implants, in order to minimize perioperative injury, and ensuring stable (but elastic) osteosynthesis (11, 17).

Genetic therapy, i.e. the attempt to create a "newly developed joint", which would replace damaged fragments of the joint, currently seems to be distant, but corresponding studies are in progress (53, 54).

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