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Usefulness of ultrasound examination in the evaluation of ulnar nerve impairment in the course of supracondylar fracture – a case report

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Abbreviations:

SCHF – supracondylar fracture of the humerus

MCP – metacarpophalangeal joint

PIP – proximal interphalangeal joint

CSA – cross – sectional area

PIN – posterior interosseous nerve

US – ultrasound

MSK – musculoskeletal

ABSTRACT

Impairments of the ulnar nerve in the courses of supracondylar fractures of the humerus (SCHF) are one of the most common complications after elbow fractures in children. A 6-year-old girl presented to the Emergency Department with the complaint of pain and reduced range of motion of the left elbow after fell on the flexed elbow. The diagnosis was supracondylar fractures of the left humerus. The patient had symptoms of paresis of the ulnar nerve after treated by closed reduction with using K-wires and immobilization in an over-elbow plaster cast. The decision to "watch and wait" was made taking into account clinical condition, findings in additional examinations, especially US. Ultrasound examinations helped to avoid unnecessary surgical treatment. After around ten months, complete resolution of symptoms was achieved. The patient recovered well.

Keywords: ultrasound, ulnar nerve, supracondylar fracture

INTRODUCTION

Supracondylar fractures of the humerus (SCHF) are widely recognized to be the most common type of elbow fractures (58%) [1] in children and amount to 16 % of all pediatric fractures [2]. These are specific to age group between 5 and 10 years old [3]. It is related to a

specific anatomy of the distal end of humerus. Humeral bone growth and remodeling in children lead to reduction of dimension in anteroposterior plane at the level of supracondylar site, as well as this part of humerus is placed between two fossas: coronoid and olecranon [4]. In addition, the distal part of humerus in children is devoid of protection as occurs of strong triceps muscle in adults[5]. Also a laxity of children's ligaments, which favors setting the joint in hyperextension, increases the risk of periarticular fractures. Majority of supracondylar fractures are the result of a fall on outstretched hand – extension type of fracture. Flexion type is less common (around 2% of all SCHF) and is a result of a fall directly on the olecranon with elbow flexed. Extension type accounts for around 90-98% of this kind of injury [5]. In both cases the energy from trauma transduced by bones of forearm finds a place of "minor resistance" in the supracondylar area resulting in fracture.

Radiography is still a golden standard in diagnosis of bone fracture but ultrasonography is already regarded as a reliable diagnostic tool in many disease entities, for example: to recognize fractures of long bones in adults and children [6,7], as well as to assess a progress of bone healing [8,9] and to monitor treatment of injuries and diseases of musculoskeletal system by physicians or by physiotherapists [10]. The main superiority of ultrasonography over an X-ray is a lack of ionizing radiance and it's harmful influence on growing tissues. It is a non-invasive and safe method, although it has also limitations from which the major one is visualization of the cortical layer of bone only.

In this paper, we present particular kind of late complications in course of flexion-type SCHF as the ulnar nerve and posterior interosseous nerve entrapment in the ubiquitous callus forming in a young girl. Various studies reported that majority of such lesions are neurapraxias which resolve intrinsically [11,12]. It was also indicated that an ultrasound is a reliable method to assess such lesion and has recently gained much attention of physicians and researchers [16]. Therefore we assessed the usefulness of ultrasound in recognizing the nature of neurological complications and in deciding on further proceedings in such cases.

CASE REPORT

A 6–year old girl fell on the flexed elbow of the left hand while playing in a common-room. She presented to the Emergency Department within the same day with the complaint of pain and reduced range of motion of the elbow. In physical examination apparent deformity, tenderness and swelling of the distal end of humerus were found. Active and passive elbow movements were restricted and painful, like also rotational movements of the forearm. There

were no distal vascular deficits. Peripheral innervation of the limb was difficult to assess accurately due to pain but there were no obvious signs of neurological deficits. Radiographs of the elbow in two planes were obtained (Fig 1,2). The injury was classified as a flexion – type supracondylar fracture in type IIIA of Gartland system for extension – type SCHF with Wilkins modification [13] and 13-A2 according to AO Classification. Closed reduction with a percutaneous insertion of two K-wires from lateral approach was proceeded with immobilization in an over-elbow plaster cast for four weeks. In the control X-ray anterior displacement of the distal fragment with anterior humeral line passing through posterior third of the humeral capitellum was noticed and accepted taking age and clinical condition into account. Findings from physical examinations from control visits are presented in Table 1.

The second follow-up

At the second follow-up, ten days after surgery, the patient started to complain of numbness in area of the fifth finger. In physical examination no deficits of superficial and deep sensation or signs of vascular compromise were revealed.

The third follow-up – no significant clinical symptoms or changes in clinical condition occurred.

The fourth follow-up

In the course of the healing process, within two weeks after plaster cast removal, symptoms of paresis of the ulnar and posterior interosseous nerves began to appear as a contracture of the fourth and fifth finger in flexion in the range of MCP and PIP with persistent dysesthesia in the fifth finger and 30˚ deficit of active extension within MCP and PIP in all fingers. Additionally, patient demonstrated 30˚ of extension deficit in the left elbow (right elbow - 10˚), range of flexion around 140˚(right elbow 160˚) and increased valgus position to 20˚(right elbow 10˚).

Nerve conduction study

Nerve conduction study was performed with the result of significant impairment of the left ulnar nerve conduction and a slight weakness of left radial nerve conduction with a debilitation of superficial sensation.

The fifth follow-up

Follow-up elbow x-rays (twelve weeks after surgery) demonstrated distal fragment bent anteriorly, and abundant callus formation with doubling the diameter of the distal humerus (Fig.3).

Ultrasound examination

Eighteen weeks after the injury ultrasound (US) examination of the left elbow was performed using GE Voluson E8 with linear probe 18 MHz and standard MSK presets. The control US examination was performed with Hitachi Aloka and linear probe 15 MHz using MSK presets. Axial and longitudinal projections was taken directly above the altered structures and about 5 cm above and below. This area was compared with the opposite, not altered, site. US revealed persistent angulation of distal end of humerus with a shift of the distal fragment anteriorly with its slight lateral displacement. Another finding was ubiquitous callus with calcifications in the condylar and supracondylar area (Fig 4a). In the assessment of neurological structures pathological findings were observed within the ulnar nerve, in the section just above medial epicondyle, as: a visible irregular contour with increased diameter and CSA at the level of around 2 cm above supracondylar (accurate measurement values in Table 2.), piecewise decreased echogenicity and multifocal effacement of fibrillary structure. Moreover, left ulnar nerve adhered to the medial epicondyle while right ulnar nerve run with slightly greater distance to the corresponding structure. The nerve in this section was surrounded with discreetly inflamed connective tissue (Fig.4b). Left posterior interosseous nerve (PIN) was without any visible structure disorders, although its distance to the bony structures was decreased in comparison to the right elbow. After ten months after fracture control US showed decrease in the diameter of ulnar nerve and a restoration of it's fibrillary structure (Fig.5).

Informed consent was obtained from the patient's parent prior to the tests. Ethics approval was obtained from Medical University Bioethics Committee in Bialystok; approval number: R-I-002/11/2016.

DISCUSSION

The group of supracondylar fractures of the humerus is saddled with a relatively high risk of complications. This is the reason for many difficulties related with the treatment. The incidence of traumatic nerve injuries was estimated in the range of 12 to 20% and for iatrogenic nerve injuries for about 2 to 6% [14] - where the majority were lesions of ulnar nerve due to percutaneous crossed K – wire fixation [12]. Injuries of radial and anterior interosseous nerves are mainly related with extension-type supracondylar fractures while ulnar nerve injuries are a sequence of the flexion-type. Neurapraxias are responsible for the majority of neurological deficits. In flexion-type SCHF it is considered that it is a consequence of the nerve being strained over the posterior edge of the proximal fragment. In such situation signs of neurapraxia are mostly visible at the admission to the Emergency

Department [15]. Mahan et al. have found that pre-operative signs of nerve injury were more commonly related with the flexion-type fracture (18%) in comparison with extension-type fracture (14%) and in each of these cases ulnar nerve was involved [16]. These symptoms normally disappear after three to six months. During this time the dynamics of neurological symptoms should be observed. If the defects does not resolve, the decision about revision of the nerve should be considered [17]. The possibility of an entrapment of a nerve into the bony structure during fracture healing is a well-known mechanism of nerve lesion [18,20,21]. However, to the authors' best knowledge, very few publications are available in the literature that discuss the issue of ulnar nerve entrapment into the forming callus in the course of supracondylar fracture healing process in children. In 1984 Lalandham and Laurence reported a case of comminuted SCHF in 6-year old girl, with late onset of ulnar nerve paralysis. Progressive symptoms occurred after two months. Revision of the nerve revealed the nerve being well incorporated in the callus formation. Ulnar nerve has been released by removal of altered section, and sutured. After a year almost complete resolution of symptoms was achieved [19]. In the second study, conducted between January 1, 1998 and December 31, 2002 in a specialist referral centre in Stanmore UK, only six children had been presenting neurological deficits from incorporation the ulnar nerve in forming callus or in fibrous tissue within the cubital tunnel. All were treated by external neurolysis [12].

In our study, onset of the ulnar nerve palsy was similar in time as in Lalandham's case study. However, the decision to observe the clinical condition was taken and another control visit was recommended. In such cases, available additional tests like nerve conduction study, may be not sufficient to assess precisely character of the nerve lesion and hence it's durability and is not adequate to define site of an injury. The second auxiliary tool used in making the decision was the ultrasound examination (US). In many studies high-resolution US was proofed to be a reliable device to define accurately the site of injury [20] and to determine the type of a nerve lesion like: compression, entrapment into bony structure, tear, neuroma [12, 21]. In a mode of grey-scale we are able to assess the morphology of a nerve, it's size and course, as well as tissues surrounding the nerve. In addition to the assessment of the nerve condition, previous reports indicated that a CSA (cross-sectional area) measurement gives more reliable information than measurement of a diameter [22].

The ultrasound image providing for incorporating the nerve into the ubiquitous callus formation gives a clue to the physician to wait for decreasing the size of the callus. Theoretically, this should go with resolving of the neurological symptoms. In our case, one

month later, physical examination revealed a maintenance of these symptoms, although with slight decrease in its intensity. After around ten months, complete resolution of symptoms was achieved with insensibly increased valgus of the left elbow.

US should be considered as a screening tool to identify patients who will benefit from early surgical intervention. It can be also a facility which help physicians to avoid unnecessary surgical treatment which can lead to post – operative side effects [23].

Conclusion

We consider, that the period in which the symptoms of nerve palsies were the most expressed can be associated with the most abundant periosteal site reaction. Both nerves, ulnar and posterior interosseous, were dislocated towards the bone structures. Additionally, ulnar nerve was clearly incorporated into the callus and altered by the surrounding inflammatory reaction which always accompanies to the healing process of fracture. The decision to "watch and wait" was made taking into account clinical condition, findings in additional examinations, especially US, and patient age, with a good result.

Conflict of interest: None declared.

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Table 1.

Number of follow-up	Days after surgery	Findings in physical examination
2nd	10	numbness in area of the fifth finger; in physical examination no deficits of superficial and deep sensation or signs of vascular compromise were revealed
4th	14	symptoms of paresis of the ulnar and PIN began to appear as set of the fourth and fifth finger in flexion in the range of MCP and PIP with persistent dysesthesia in the fifth finger; additionally 30˚ of extension deficit in the left elbow (right elbow - 10˚), range of flexion around 140˚(right elbow 160˚) and increased valgus position to 20˚(right elbow 10˚); within MCP and PIP in all fingers - 30˚ of active extension deficit
5th	84	In X-ray: distal fragment bent anteriorly, abundant callus formation with doubling the diameter of the distal humerus diameter (Fig.3)

Table 2.

	CSA (2 cm above supracondylar)	Diameter (2 cm above supracondylar)
Left ulnar nerve	6.02 mm2	2.54 mm
Right ulnar nerve	4.54 mm2	0.8 mm

Figure captions

Fig. 1 Pre-operative X-rays showed fissure of fracture in the supracondylar area with anteromedial displacement of the distal fragment with its rotation and no contact between proximal and distal fragments preserved

Fig.2 Post-operative X-rays: anterior displacement of the distal fragment with anterior humeral line passing through posterior third of the humeral capitellum

Fig.3 Follow-up X-ray after 3 months

Fig. 4a Ubiquitous callus formation with calcifications in the supracondylar area (anterolateral site)

Fig. 4b Left and right ulnar nerves in ultrasound examination after eighteen weeks after surgery

Fig. 5 Ultrasound of the left ulnar nerve after ten months after fracture shows decrease of the diameter of the nerve as well as restoration of its fibrillary structure

Fig. 6 (L) Control lateral X-ray of the left elbow after 10 months after surgery: distal end of humerus bent in the posterior direction during remodelling

Fig. 7 Comparative image in AP projection obtained in the same time as lateral films above, shows further remodelling of the distal end of humerus with increased valgus position maintaining in the same degree since the plaster cast removal (around 20 degrees).

Fig.1

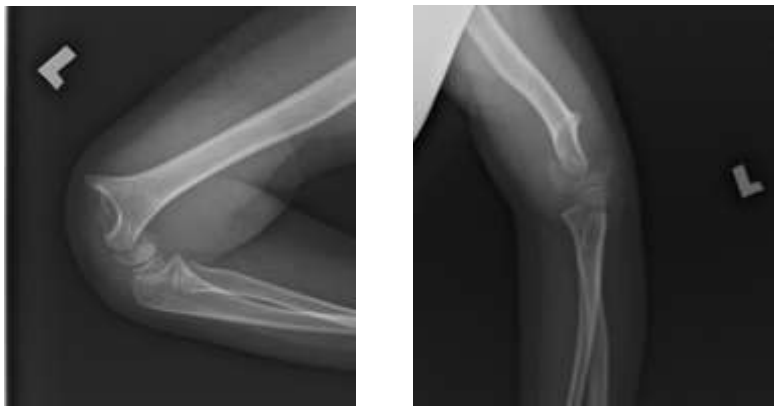

Fig.2

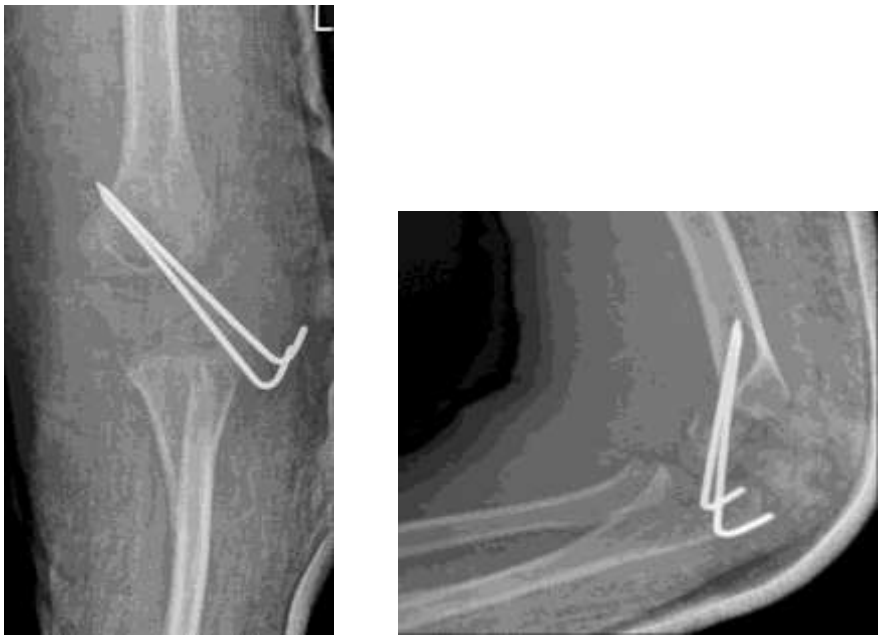

Fig.3

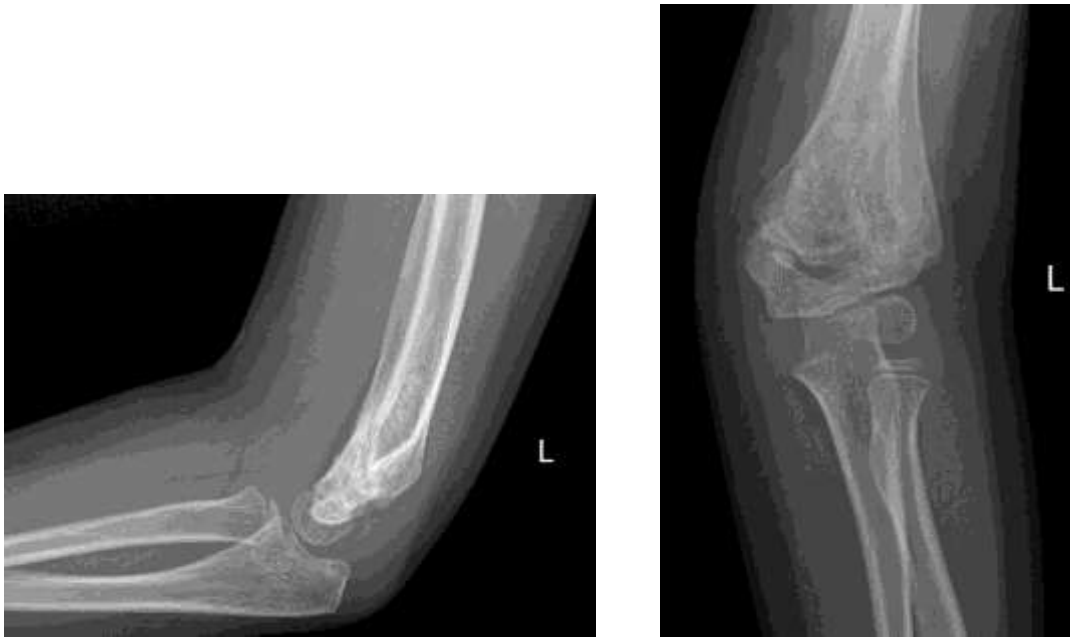

Fig.4a

Fig.4b

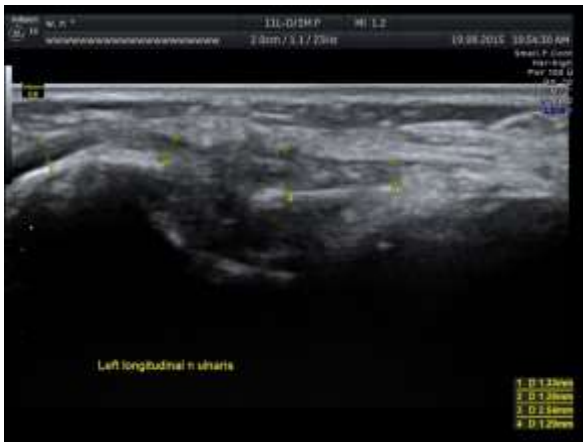

Fig.5

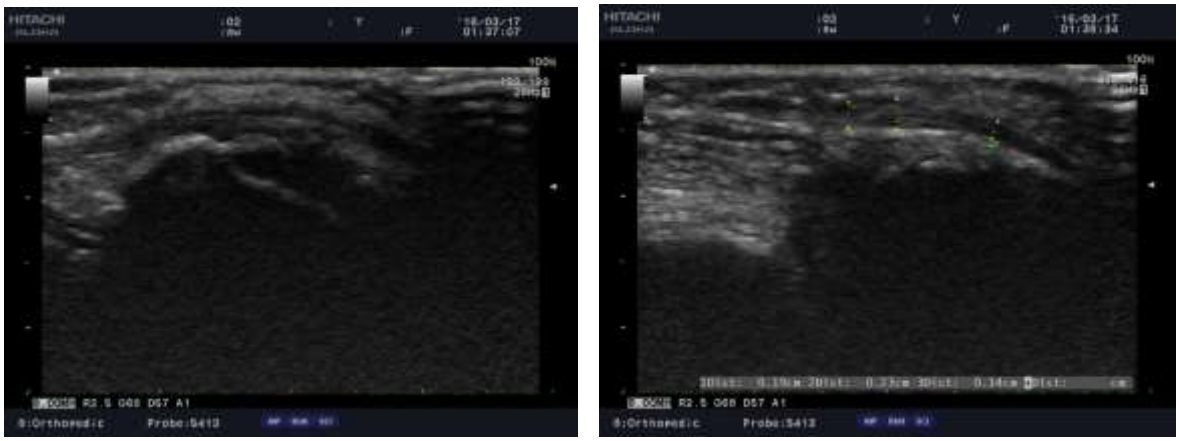

Fig.6

Fig.7