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Is Attention Deficit and Hyperactivity Disorder a Risk Factor for Sustaining Fractures of Proximal Humerus?

Je porucha pozornosti a hyperaktivita u dětí rizikovým faktorem pro vznik zlomeniny proximálního humeru?

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ABSTRACT

PURPOSE OF THE STUDY

To evaluate whether or not children with displaced proximal humerus fractures are more likely to have attention deficit and hyperactivity disorder (ADHD).

PATIENTS AND METHOD

Between January 2010 and February 2013, we retrospectively evaluated 42 children with proximal humerus fractures. Requirements for inclusion were an open epiphyseal plate and a non-pathological fracture of the proximal humerus. Fractures were classified according to Salter-Harris, Neer and Horwitz. Following orthopaedic examination, all of the children were consulted to child psychiatry department of our hospital. Orthopaedic examination included a detailed physical examination; the assessment of the overall shoulder functions using the Constant score. Diagnostic and Statistical Manual of Mental Disorders, Text Revisions (DSM-IV-TR) were used for psychiatric examination.

RESULTS

9 of the 42 children with proximal humerus fractures consulted to child psychiatry were put ADHD diagnoses (21 %). Of the remaining 33 children without ADHD diagnosis, 5 children were operated; percentage of surgery was 15%. We found statistically significant difference between the rates of ADHD diagnosed children with proximal humerus fractures and ADHD diagnoses in normal population ($p<0.01$). There was also statistically significant difference between operation rates of children with or without ADHD diagnosis (55 % vs. 15 %) ($p<0,01$).

CONCLUSIONS

ADHD can be accepted as a risk factor for sustaining high energy trauma and rate of ADHD children who were operated was significantly more than normal children. This might be due to more displaced, open fractures or polytrauma – higher energy trauma- they sustained. Deciding on the treatment method, surgery may be treatment of choice in certain children with severely displaced, irreducable, fractures or polytrauma with accompanying ADHD due to the potential difficulties during follow up period.

Key words: attention deficit hyperactivity disorder, proximal humerus fracture, pediatric, closed reduction, percutaneous pinning.

INTRODUCTION

Fractures of the extremities are frequent causes for hospitalisation and operations of pediatric population. Extremity fractures of children are mostly due to accidental and non-accidental trauma (child abuse) and pathologic conditions. Attention deficit and hyperactivity disorder (ADHD) is a chronic disorder characterized by attention deficit, hyperactivity, conduction and impulse control problems (8, 11, 15, 43, 48, 56). In literature, there are many studies about extremity fractures of children with ADHD. In most of these studies children with this condition were found to be at higher risk for sustaining trauma.

Proximal humeral fractures usually result from high energy direct forces (6, 12, 20, 23, 24, 31). If the fracture has occured following minor trauma, a pathologic fracture should be investigated .(2, 19, 26, 35, 42). Among the children with proximal humerus fractures, the proportion of ADHD diagnosed children to their healthy peers may be more due to their susceptibility to sustain more severe injuries than children without ADHD.

Surgical fragment fixation is primarily indicated in more fracture types of proximal humerus, particularly in polytraumatized patients, irreducible and open fractures (27, 44). We hypothesized that children with displaced fractures of proximal humerus are more likely to have ADHD compared to normal population and closed reduction and percutaneous pinning may be treatment of choice for some of these displaced fractures due to their incompatibility to conservative treatment.

PATIENTS AND METHODS

Consent to study participation was obtained from families. Between January 2010 and February 2013, we retrospectively evaluated 42 children with proximal humerus fractures. The mean age of the children was 9.5 (5–16 years). Requirements for inclusion were an open epiphyseal plate and a non-pathological fracture of the proximal humerus. Fractures were classified according to Salter-Harris, Neer and Horwitz (37, 45).

In 30 cases, presentation was immediately after the trauma; the other children presented after a mean time of 3.2 days (range 1 to 4 days). Three children had multiple injuries. 28 of the cases were metaphyseal fractures, 14 of them were epiphyseal separations. Among these injuries, 2 of them were type1 and 12 were type 2 according to the Salter-Harris classification. According to Neer and Horwitz classification, there were 6 grade 1, 6 grade 2, 16 grade 3 and 14 grade 4 fractures. Overall 27 of the patients were treated with a shoulder immobilizer and in 5 patients a hanging cast was applied. General indication for operative treatment in our study was 11 or more years of age and fractures that did not reach a satisfactory reduction.

10 children who had polytrauma or a severely displaced fracture were operated by closed reduction and percutaneous pinning. 3 of them were open fractures. Remaining 32 children were followed up conservatively.

Surgery was performed under general anesthesia, in a beach chair position with side placement of an image intensifier to be able to view proximal humerus in two planes. Reductions were maintained with appropriate maneuvers (gentle longitudinal traction in an abduction position with external rotation of the arm) and were percutaneously fixed by using 2 or more K-wires. Mean operation time was 41 minutes. Following surgery, a similar rehabilitation program was performed to all of the patients. Early passive and active motion exercises were started. A sling was used postoperatively and patients started passive ROM exercises at early postoperative period. After radiologic evidence of fracture healing was seen active exercises were begun. Implant removal was performed after duration of 6 to 10 weeks dependent on fracture healing.

Because ADHD is a chronic disorder a mean of 24 months (6–41 months) after the operation, we called these 42 children for psychiatric examination with their families. Following orthopaedic examination, all of the children were consulted to child psychiatry department of our hospital. Orthopaedic examination included a detailed physical examination; the assessment of the overall shoulder functions using the Constant score22. The constant scoring system involved subjective assessments of pain and activities of daily living, for which, out of a total of 100 points, a maximum value of 15 and 20 points were allocated. In addition, objective measurements of the active range of movement and power could receive additional maximum values of 40 and 25 points. Power measurement for the Constant score was standardized using a digital spring balance in myometer. Results of more than 71 points were good, and more than 86 points were rated as excellent. Following orthopaedic examination patients were referred to Child psychiatry department. Diagnostic and Statistical Manual of Mental Disorders, Text Revisions (DSM-IV-TR) were used for psychiatric examination (3) (Table 1).

RESULTS

9 of the 42 children with proximal humerus fractures consulted to child psychiatry were put ADHD diagnoses (21%). ADHD percentage in normal population is estimated to be 5.29%. Five of the children who received surgical treatment were found to be ADHD and 4 of the children with ADHD diagnosis were followed up conservatively. Among 9 children with ADHD diagnosis the percentage of children who underwent closed reduction and percutaneous pinning was 55%. Of the remaining 33 children without ADHD diagnosis, 5 children were operated, percentage of surgery was 15%. We found statistically significant difference between the rates of ADHD diagnosed children with proximal humerus fractures and ADHD diagnoses in normal population ($p<0.01$). There was also statistically significant difference between operation rates of children with or without ADHD diagnosis (55% vs. 15%) ($p<0.01$). 8 patients who were younger than 11 years and 34 were older than 11 years. No loss of reduction was observed during fracture-healing time (Figs 1, 2 and 3). Complications such as postopera-

Table 1. Diagnostic and statistical manual of mental disorders, text revisions (DSM-IV-Tr) diagnostic criteria for ADHD

I. Either (A) or (B)	
(A) Six or more of the following signs of inattention have been present for at least 6 months to a point that is disruptive and inappropriate for developmental level Inattention Often does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities Often has trouble keeping attention on tasks or play activities Often does not seem to listen when spoken to directly Often does not follow instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions) Often has trouble organizing activities Often avoids, dislikes, or doesn't want to do things that take a lot of mental effort for a long period of time (such as schoolwork or homework) Often loses things needed for tasks and activities (such as toys, school assignments, pencils, books, or tools). Often easily distracted . Often forgetful in daily activities	**(B) Six or more of the following signs of inattention have been present for at least 6 months to a point that is disruptive and inappropriate for developmental level** Hyperactivity Often fidgets with hands or feet or squirms in seat. Often gets up from seat when remaining in seat is expected. Often runs about or climbs when and where it is not appropriate (adolescents or adults may feel very restless). Often has trouble playing or enjoying leisure activities quietly Is often "on the go" or often acts as if "driven by a motor" . Often talks excessively Impulsiveness Often blurts out answers before questions have been finished . Often has trouble waiting one's turn. Often interrupts or intrudes on others (example: butts into conversations or games)
II. Some signs that cause impairment were present before age 7 years	
III. Some impairment from the signs is present in two or more settings (such as at school/work and at home).	
IV. There must be clear evidence of significant impairment in social, school, or work functioning	
V. The signs do not happen only during the course of a pervasive developmental disorder, schizophrenia, or other psychotic disorder. The signs are not better accounted for by another mental disorder (such as mood disorder, anxiety disorder, dissociative identity disorder, or a personality disorder)	

Table 2. Mean Constant scores

	CR and PF	**Conservative**	**p**
ADHD (+)	89.4 (n=5)	89.8 (n=4)	>0.05
ADHD (-)	87.6 (n=5)	89.2 (n=28)	>0.05
Overall	88.5	89.3	>0.05
Total (N)	10	32	

ADHD – attention dedicit-hyperactivity disorder, CR and PF – closed reduction and percutaneous fixation, N – number of patients

Fig. 1. Preoperative view.

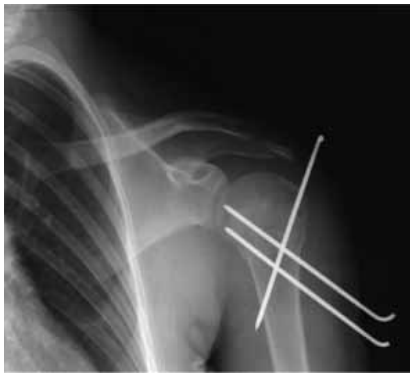

Fig. 2. Postoperative view.

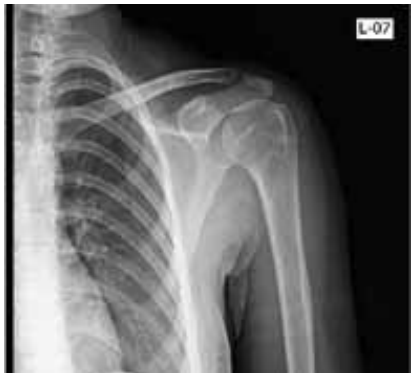

Fig. 3. Late postoperative view.

tive infections, loss of reduction of the fracture, pseudarthrosis, humeral head necrosis, or implant breakage was noted at final follow-up.

At a mean follow up of 24 months (6 to 41 months) , mean Constant scores were 88.5 in the operated group (n=10) and 89.3 in the non-operated group (n=32) respectively and among the children with ADHD diagnosis mean constant score of the operated (n=5) and non-operated children (n=4) were 89.4 and 89.8 respectively. Mean Constant scores of the children without ADHD diagnosis were 87.6 in the operated (n=5) and 89.2 in the non-operated group (n=28), respectively. There was no statistical significance between the groups (Table 2).

DISCUSSION

Attention deficit/hyperactivity disorder (ADHD) is a developmental neurobehavioral disorder characterized by co-existence of attention problems, hyperactivity, and impulsivity that leads to functional impairment. It is one of the common psychiatric disorders among children with an estimated rate of 5.29 % of all children in school age (39). In the literature there are many studies about the increased susceptibility of children with ADHD to accidental and unintentional injuries (4, 8, 11, 15, 29, 38, 43, 48, 49, 51). Accidental trauma usually occurs as a result of falls (while running

or from a height), also playground activities, bicycle riding, fighting, and motor vehicle accidents are the main causes of trauma.30

Bruce et al. (9) in their study proposed that risk perception of children with ADHD might be impaired which is responsible for their risk taking behavior thus experiencing more injuries. Injuries in ADHD children may be caused by variety of reasons certain behavioral characteristics of the disorder such as reckless behavior, clumsiness, inability to abide by the rules of play or sports, neglecting to take safety precautions during activities and difficulties in relationships with peers may all contribute occurrence of injuries.

In their study Farmer et al. (17) found that children with ADHD were not capable as their normal peers to anticipate prevention strategies and safety rules for risky behaviors. In another study it was found that children with ADHD showed defective protective reactions and slower reaction times in experimental situations (1, 30).

If there is a suspicion of ADHD, possible refractures of these children should be investigated. General behaviors of the children should be asked to their parents like difficulty of the children while remain seated, clumsiness, inattention, hyperactivity, initiating physical fights (28) and if any suspicion occurs, these children must be consulted to a child psychiatry specialist.

Even though the relation of childhood injury risk and ADHD seems clear from literature controlled prospective studies are lacking. In their study Uslu et al. found out that children with lower extremity fractures had a higher mean Conner's Parent Rating Scale (CPRS) impulsivity/hyperactivity subscale score than that of children with upper extremity fractures36. However, according to the data from this study rate of ADHD was significantly higher in children with proximal humeral fracture than estimated rate in normal population. Rate of lower extremity fractures of children with ADHD compared to their normal peers may be investigated in later studies.

Proximal humeral fractures are generally result of high energy trauma (6, 27, 44). They are rare and occur in approximately 2.2 to 4.5 per 1000 individuals of all physeal injuries per year (22, 33, 55).

Fractures of the proximal part of the humerus in children have a huge remodeling potential because of a longitudinal humerus growth (5, 7, 40, 41). Because of the age dependency of the remodeling capacity, excellent therapeutic results after proximal humeral fractures are expected in children younger than 11 years regardless of the amount of displacement and angulation (14, 34, 37) However recent studies favor a surgical approach in older adolescents with severely displaced or angulated fractures due to the decrease in potential remodeling capacity. In one study, it was stated that humeral remodeling only partially corrected fracture angulations in patients older than 11 years (14, 46).

Fractures of the proximal humerus occur more often in younger children; physeal injuries of the proximal humerus may occur in children of any age, but occur more commonly in adolescents (47).

The forces responsible for a proximal humerus injury may act with a mechanism of compression, inclination, flexion, shear, and torsion. Torsion forces generally produce fractures below the tuberosities, whereas shear forces usually cause epiphyseal separations. Conservative treatment is the treatment of choice for most epiphyseal and metaphyseal fractures of the proximal humerus in children (47). Even significantly angulated and displaced fractures have achieved union in positions that have allowed for normal or near-normal functional outcome. In girls under 13 and boys under 15 years of age, 50% of bayonet apposition of a proximal humerus fracture and up to 20° of angulation in any plane has been noted to remodel (50). Besides, in children up to 10 years of age, axial malalignment of the proximal humerus of as much as 60° in varus, anteversion, or retroversion can be corrected by remodeling (18). However, beyond 10 years of age, the remodeling potential is not as high and correction can be expected only with axial deformities of up to 20–30° (18). Absolute criteria for the amount of displacement and angulation as an indication for surgical fixation have not been clearly established. Burgos-Flores et al. described their operative indications as a fracture with lateral displacement of 50% of the bone width or over 30% angulation (10). However, in their study Dameron and Reibel evaluated 46 patients with proximal humeral physeal injuries and noted poor outcomes in patients aged 14 years or older who lost fracture reduction during the treatment period (45). In some studies, rate of attempted but failed acceptable reductions in severely displaced fractures were found to be roughly 20% to 90% of the cases (5, 16, 22, 36, 37). Reasons of reduction loss has been investigated and soft tissue entrapment, particularly long head of biceps has been mentioned before (16, 21, 25, 32, 37, 53)

Indications for surgery reported in the literature are limited: 1. irreducible fractures (due to interposition of the periosteum or of the long head of the biceps tendon); 2. insufficient reduction in patients near skeletal maturity; 3. displaced or unstable fractures in patients who do not tolerate any immobilization (polytraumatized, myopathic, spastic, etc.): in these cases stable fixation will be required, like in adult patients; 4. open fractures or fractures associated with vascular or nervous lesions. There are many studies in literature regarding reduction and open or closed fixation in severely displaced fractures in older patients (46, 50, 54). The use of percutaneously placed pins to stabilize fractures of the proximal humerus has been well described (10, 25, 46).

DiScala et al. (15), in their study found that children with ADHD were significantly more likely to sustain severe trauma compared to normal children. In our study we found that percentage of ADHD diagnosed children with proximal humerus fractures was significantly higher than that of ADHD diagnoses in normal population. Conservative treatment of ADHD children with fractures is more difficult compared to normal. Thus, closed reduction and percutaneous pinning may be used

for polytraumatized patients or for severely displaced, irreducible fractures of the proximal humerus in children with ADHD.

CONCLUSIONS

Due to the fact that children with ADHD are more susceptible to injuries, orthopaedic surgeons when compared to other specialists, are more likely to face these children at emergency hall. Therefore, they must be aware of the characteristic symptoms of this disorder to be able to consult these children to child psychiatry specialist.

In our study, we did not find any significant difference about fracture healing between children who were surgically treated and who were followed up conservatively. In literature there are many studies regarding conservative treatment of proximal humerus fractures and they have satisfactory results. Our results were also satisfactory in means of clinical results of surgery and conservative treatment. According to our results, ADHD can be accepted as a risk factor for sustaining high energy trauma and rate of ADHD children who were operated was significantly more than normal children. This might be due to more displaced, open fractures or polytrauma – higher energy trauma- they sustained. Deciding on the treatment method, surgery may be treatment of choice in certain children with severely displaced, irreducible, fractures or polytrauma with accompanying ADHD due to the potential difficulties during follow-up period.

Conflict of interest

Each author certifies that he or she or a member of his or her immediate family, has no funding or commercial associations (e.g., consultancies, stock ownership, equity interest, patent licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

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