Oxygen saturation measurement in dislocated supracondylar fractures in children

Pomiar saturacji krwi tętniczej w przemieszczonych złamaniach nadkłykciowych kości ramiennej u dzieci

Łukasz Matuszewski, Michał Budkowski, Tomasz Lach, Wojciech Grodzicki
Pediatric Orthopedy and Rehabilitation Department Medical University in Lublin, Lublin, Poland

Abstract
The goal of his study was to show that oxygen saturation measurement in the distal part of injured upper extremity is one of the best method to assess post-traumatic blood flow disturbances and the necessity for exploration of brachial artery in supracondylar fractures. 32 children, age 4-16, with Garland's displaced extension type III injuries and distal disruption of blood flow were treated between 2014 and 2018. Blood disturbances were measured by pulse oximeter. Very good or good results were achieved in 22 non-operatively treated patients where pulseless pink hand symptoms occurred and, after reduction, disappeared. Very good or good results were achieved in 9 patients with pulseless pale and cold hand symptoms. In one patient with pulseless hand (verified by pulse oximeter) but without symptoms of cold hand we decided to explore brachial artery after angio CT examination (Angio-CT showed complete entrapment of the brachial artery). In conclusion we think that oxygen saturation measurement in dislocated supracondylar fractures in children is the best method. It allows us determine whether to avoid or to perform exploration of brachial artery. It is also easily accessible in comparison to the Doppler US or other imaging tools.

Key words: fracture, supracondylar, children, pulse oximeter, brachial artery

Słowa kluczowe: złamania, nadkłykciowe, dzieci, pulsoksymetr, tętnica ramieniowa

 ORIGINAL PAPER

Oxygen saturation measurement in dislocated supracondylar fractures in children

Pomiar saturacji krwi tętniczej w przemieszczonych złamaniach nadkłykciowych kości ramiennej u dzieci

Łukasz Matuszewski, Michał Budkowski, Tomasz Lach, Wojciech Grodzicki
Pediatric Orthopedy and Rehabilitation Department Medical University in Lublin, Lublin, Poland

Abstract
The goal of his study was to show that oxygen saturation measurement in the distal part of injured upper extremity is one of the best method to assess post-traumatic blood flow disturbances and the necessity for exploration of brachial artery in supracondylar fractures. 32 children, age 4-16, with Garland's displaced extension type III injuries and distal disruption of blood flow were treated between 2014 and 2018. Blood disturbances were measured by pulse oximeter. Very good or good results were achieved in 22 non-operatively treated patients where pulseless pink hand symptoms occurred and, after reduction, disappeared. Very good or good results were achieved in 9 patients with pulseless pale and cold hand symptoms. In one patient with pulseless hand (verified by pulse oximeter) but without symptoms of cold hand we decided to explore brachial artery after angio CT examination (Angio-CT showed complete entrapment of the brachial artery). In conclusion we think that oxygen saturation measurement in dislocated supracondylar fractures in children is the best method. It allows us determine whether to avoid or to perform exploration of brachial artery. It is also easily accessible in comparison to the Doppler US or other imaging tools.

Key words: fracture, supracondylar, children, pulse oximeter, brachial artery

Słowa kluczowe: złamania, nadkłykciowe, dzieci, pulsoksymetr, tętnica ramieniowa

Streszczenie
Wstęp. Celem tej pracy jest potwierdzenie, iż pomiar saturacji krwi tętniczej w dystalnej części kończyny górnej jest jedną z najlepszych metod na ocenę postrawnego zaburzenia przepływu krwi i konieczności rewizji tętnicy ramiennej w przypadku złamań nadkłykciowych kości ramiennej. 32 dzieci, w wieku od 4 do 16 lat, po przemieszczonym wyprostnym złamaniu nadkłykciowym typu III wg Garlanda i z zaburzeniami przepływu w dystalnej części kończyny górnej było leczonych w latach 2014 do 2018. Oceny zaburzeń ukwienia dokonywano za pomocą pulsoksymetru. Bardzo dobre i dobre wyniki zostały uzyskane u 22 pacjentów, u których zastosowano leczenie bezoperacyjne i gdzie występował objaw „pulseless pink hand” i po nastawieniu złamania ustąpiły. Bardzo dobre i dobry wyniki uzyskano u 9 pacjentów, u których występowały objawy „pulseless pale and cold hand”. W jednym przypadku braku pulsu potwierdzonym pulsoksymetrem, lecz bez innych objawów zaburzeń przepływu krwi zdecydowano na rewizję tętnicy ramiennej po wykonaniu badania angio-TK (uwidoczniło ono całkowite zakleszczenie tętnicy między odłamami złamania). Pomiar saturacji krwi tętniczej w odcinku dystalnym kończyny górnej w przemieszczonych złamaniach nadkłykciowych u dzieci jest najlepszą metodą pozwalającą ocenić potrzebę wykonania otwartej rewizji tętnicy ramiennej. Jest to także metoda łatwo dostępna w porównaniu z USG Doppler czy innymi badaniami obrazowymi.

Słowa kluczowe: złamania, nadkłykciowe, dzieci, pulsoksymetr, tętnica ramieniowa
Introduction

Supracondylar fractures of the humerus are the most common injuries in the elbow region in children standing on 60% of all fractures [1,2]. This type of fracture is located outside of joint capsule and occurs mostly due to indirect mechanism. In extension type, which is most frequent, distal section of humerus is displaced to the back and, most commonly, rotated laterally [3] (Fig. 1). According to Campbell et al., this displacement predisposes to brachial artery and medial nerve damage. Extension type fracture with posteromedial displacement is rather responsible for radial nerve injury and flexion type fracture goes along with ulnar nerve disturbance [4].

To state whether brachial artery exploration is needed, pulse oximeter might be not only serviceable but also precise decision-maker (Fig. 3).

Fig. 1. X-ray that shows Gartland's III type supracondylar humerus fracture.

Fig. 2. Adventitial hematoma and artery spasm.

Fig. 3. Pulse oximeter.

Aim

The main goal of this study is to show the usefulness of pulse oximeter on the example of diagnosing and treating supracondylar fractures of the humerus with hemodynamic complications. Those said complications include signs of vascular compromise and poor blood perfusion: pain on a passive stretch of the wrist, failure to record oxygen saturation, absence of capillary refill, low hand’s temperature [11]. Necessary steps in treatment of pulseless cold hand are straightforward [6] but the management of the pulseless perfused hand in association with a supracondylar humerus fracture remains controversial. Some authors have suggested the use of color-flow duplex monitoring, magnetic resonance angiography and segmental pressure monitoring as objective steps to ascertain blood flow following adequate internal fixation. We analyze the use of the pulse oximetry to objectively determine perfusion of injured limb after reduction and in predicting the need for surgical exploration in patients who
present with a blood flow disturbances coexisting with supracondylar fracture of the humerus.

Material and method

This paper covers 32 cases of children, aged between 4 and 16, with Garland's displaced extension type III injuries and distal disruption of blood flow. All patients were treated in years 2014-2018. Blood flow disturbances were measured by pulse oximeter and carefully evaluated by clinical examination. Each electronic record was reviewed and limbs with absent radial pulse following admission were identified. X-ray films of each of the patients were reviewed. Follow-up analysis concerned a period of 12 to 24 months after injury. During clinical examination we used Flynn's scale (modified by Tempelton and Graham) to evaluate functions of the elbow joint, forearm and wrist. Flynn's scale allows us to monitor functional limitation of the range of motion compared with the uninjured side.

Results

We examine the use of the waveform of the pulse oximeter to determine a blood perfusion of the limb and in predicting the need for surgical exploration in patients who presents with a pulseless hand after injury (Fig. 3). In 22 cases after closed reduction pulse oximeter waveforms were present. Those patients presented pulseless pink hand symptoms and were treated non-operatively with very good or good results. 9 children had pulseless pale and cold symptoms after reduction, pulse oximeter waveform was absent and had undergone operative brachial artery revision with very good or good results in 9 cases. One patient with pulseless hand verified by pulse oximetry but without initial clinical signs of perfusion disturbance was qualified for angio-CT examination and consequently underwent artery exploration.

We performed surgical exploration of the brachial artery in 9 patients no more than 8 hours after injury. Pulseless pale hand symptoms and severe pain together with the lack of waveform of the pulse oximeter in upper limb region were identified. During 10 open artery revisions we noticed: brachial artery and median nerve contusion or isolated brachial artery contusion. What is most important we did not notice any perfusion disorders in patients with absent radial pulse but with the normal waveform of the pulse oximeter. Pulse on the radial artery returns within 48-72 hrs after injury. We also didn't notice any late growth or function disorders in patients with normal waveform of the pulse oximeter but with absent radial pulse. In follow-up analysis concerned a period of 12 to 24 months after injury we used Flynn's scale (modified by Templeton and Graham) to achieve 95% good or very good results in both groups.

Conclusion and discussion

Lesions of the brachial artery coexisting with supracondylar fracture of the humerus are rather rare. Throughout years 1984-2002 in our Department only 3.6% out of 786 fractures were operated with exploration of cubital fossa. Although hemodynamic and neurological complications are not so common, patients may present both or even brachial artery injury with multi upper limb nerve insufficiency [6, 12].

For some time we have been witnessing decrease in necessity for brachial artery exploration. This trend is caused by development of better diagnostic tools and an improvement in methods of treatment (ultrasound and C-arm X-ray) [6]. Despite infrequent direct arterial damage that occurs with this common injury the orthopaedist must always assess regularity in functioning of the brachial artery. As we mentioned earlier complications from imperfect procedure may be massive.

When it comes to crucial step required for proper management of supracondylar fracture the reduction itself is considered to be of utmost importance [4,13,14]. Without anatomical arrangement of the humeral bone steps that follow lose effectiveness.

Morphology of arterial damage is diverse. Contusions, with or without the spasms, are the most popular causes of hemodynamic brachial artery insufficiency and also that there is no correlation between the signs of ischemia and the type of brachial injury [15]. Nowadays, the quality of vascular surgery allow us to obtain satisfying results of brachial artery repairment, and what follows, a high positive clinical outcome after arterial damage. In this study all methods of treatment lead to good or very good results and those findings agree with other authors [1,5].

The pulse oximeter is an excellent and readily available tool in the emergency department and the operative room to assess indications for revision of the brachial artery in children with supracondylar humerus fractures. Other methods used to assess blood flow, according to some authors, may be unnecessary [9]. The presence of a waveform on a pulse oximeter is a sensitive, available modality in assessing vascular perfusion as compared to other more complex and less available investigations [16]. According to Sabharwal et al. angiography or MRA, although both technically viable and safe, had a high rate of asymptomatic reocclusion and residual stenosis of the brachial artery [6,17]. Some authors are of the opinion that the lack of radial pulse is equal with arterial injury. They suggest vascular exploration and repair in selected cases [9, 16, 18]. Other authors and clinicians point on observation in situation when the pulse is non-existent but there are no others sings of blood-flow disturbances [19-22].
Limitations of the study

We’ve noticed that our study shows a positive predictive value for exploration of the brachial artery. However, we’ve had one patient with a good blood supply of the distal part of the limb but with complete entrapment of the brachial artery that needed operative exploration – a case of a patient with both hemodynamic and neurological complications [12].

The upper limb has an extremely good collateral blood supply which comes from the superior and inferior ulnar collateral artery medially and the deep brachial artery laterally. Does it means that patients with good perfusion but with absent of radial pulse exploration of brachial artery is necessary? In personal experience as orthopedic surgeons: children have enormous healing potential and the brachial artery injuries may resolve spontaneously.

References