




Acute vascular complications in pediatric patients with supracondylar humeral fractures

Complicaciones vasculares agudas en pacientes pediátricos con fracturas supracondíleas del húmero

Complicações vasculares agudas em pacientes pediátricos com fraturas supracondilíneas do úmero

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ABSTRACT

Introduction: supracondylar fractures of the humerus in children are associated with acute complications such as vascular complications that endanger the viability of the affected limb.

Objective: to systematize acute vascular complications in patients with supracondylar fracture of the humerus in children. **Method:** the search and analysis of the information was carried out over a period of 61 days (December 1, 2023 to January 31, 2024) and the following words were used: pediatric supracondylar humeral fractures AND vascular injury, pulseless hand AND pediatric supracondylar humeral fracture, complex fracture, compartment syndrome. Based on the information obtained, a bibliographic review of 186 articles published in the databases was carried out. **Results:** reference is made to the behavior of the articles in the PubMed database in the last 10 years. The main characteristics of vascular lesions are

mentioned in terms of their exploration and forms of presentation. The use of Doppler ultrasound and arteriography in these patients is discussed, as well as the procedure to follow. In relation to compartment syndrome, the incidence, forms of presentation and behavior to follow are described. **Conclusions:** acute vascular complications related to supracondylar fracture in pediatric patients constitute a challenge for medical personnel. Its variants are multiple with different interpretation and implementation, most of the complementary exams provide insufficient elements in the initial stages.

Keywords: pediatric supracondylar humeral fracture; vascular injury; complications; vascular repair; compartment syndrome



RESUMEN

Introducción: las fracturas supracondíleas del húmero en niños se asocian con complicaciones agudas como las vasculares que ponen en peligro la viabilidad del miembro afectado. **Objetivo:** sistematizar sobre las complicaciones vasculares agudas en pacientes con fractura supracondílea del húmero en niños. **Método:** la búsqueda y análisis de la información se realizó durante un período de 61 días (1 de diciembre de 2023 al 31 de enero de 2024) y se utilizaron las siguientes palabras: *pediatricsupracondylar humeral fractures* AND *vascular lesion, pulseless hand* AND *pediatric supracondylar humeral fracture, complex fracture, compartment syndrome*. A partir de la información obtenida se realizó una revisión bibliográfica de un total de 186 artículos publicados en las bases de datos. **Resultados:** se hace referencia al comportamiento de los artículos en la base de datos PubMed en los últimos 10 años. Se mencionan las principales características de las lesiones vasculares en cuanto a su exploración y formas de presentación. Se aborda el uso de la ecografía *doppler* y la arteriografía en estos pacientes, así como la conducta a seguir. En relación al síndrome compartimental se describe la incidencia, formas de presentación y conducta a seguir. **Conclusiones:** las complicaciones vasculares agudas relacionadas con la fractura supracondílea en pacientes pediátricos constituyen un desafío para el personal médico. Sus variantes son múltiples con diferente interpretación y realización, la mayoría de los exámenes complementarios aportan elementos insuficientes en las etapas iniciales.

Palabras clave: fractura supracondílea humeral pediátrica; lesión vascular; complicaciones; reparación vascular; síndrome compartimental

RESUMO

Introdução: as fraturas supracondilianas do úmero em crianças estão associadas a complicações agudas, como complicações vasculares que colocam em risco a viabilidade do membro afetado. **Objetivo:** sistematizar complicações vasculares agudas em pacientes com fratura supracondiliana de úmero em crianças. **Método:** a busca e análise das informações foram realizadas durante um período de 61 dias (1º de dezembro de 2023 a 31 de janeiro de 2024) e foram utilizadas as palavras: *pediatricsupracondylar humeral fractures* AND *vascular lesion, pulseless hand* AND *pediatric supracondylar humeral fracture, complex fracture, compartment syndrome*. Com base nas informações obtidas, foi realizada uma revisão bibliográfica de um total de 186 artigos publicados nas bases de dados. **Resultados:** faz-se referência ao comportamento dos artigos na base de dados PubMed nos últimos 10 anos. São citadas as principais características das lesões vasculares quanto à sua exploração e formas de apresentação. Discute-se o uso da ultrassonografia Doppler e da arteriografia nesses pacientes, bem como o procedimento a seguir. Em relação à síndrome compartimental são descritas a incidência, formas de apresentação e comportamento a seguir. **Conclusões:** as complicações vasculares agudas relacionadas à fratura supracondiliana em pacientes pediátricos constituem um desafio para a equipe médica. As suas variantes são múltiplas com diferentes interpretações e implementações, a maioria dos exames complementares fornecem elementos insuficientes nas fases iniciais.

Palavras-chave: fratura supracondiliana do úmero pediátrica; lesão vascular; complicações; reparação vascular; síndrome compartimental

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INTRODUCTION

Supracondylar fractures of the elbow in pediatric ages are the most frequent fractures of this joint. Generally, they are displaced fractures that require intervention and hospitalization, as they are usually associated with complications.^(1,2,3)

The main objective of treatment in this group of patients is to avoid complications, which may be immediate or delayed. The first group includes: open fractures, neurological and vascular lesions, among others.^(4,5,6)

The most frequent immediate vascular injuries are those related to the brachial artery and compartment syndrome. The incidence of vascular complications in patients with type III fractures in extension according to the Gartland classification varies from 2 to 38% according to Brandt, et al.⁽⁷⁾ The affection of the blood irrigation derives in aesthetic and functional sequelae or total or partial loss of the extremity.⁽⁸⁾

To corroborate the clinical diagnosis of these vascular entities, imaging tests such as Doppler ultrasound, arteriography and measurement of compartment pressures are required.⁽⁹⁾

Early diagnosis allows taking effective measures to reduce the magnitude of the injury or reverse the effects of the loss of blood supply, these medical actions can be from the simple opening of the immobilization and extension of the elbow to the most complex surgery that requires the action of the orthopedist and the vascular surgeon.^(10,11)

Due to the importance of this issue in pediatric traumatology and the scarce information available on this subject in the national and international literature, a narrative bibliographic review of this entity was carried out with the aim of updating on acute vascular complications in pediatric patients with supracondylar fracture of the humerus.

METHOD

A narrative literature review was carried out. The search and analysis of the information was conducted over a 61-day period (December 1, 2023 to January 31, 2024) and the following words representing the variables of analysis were used: *pediatric supracondylar humeral fractures* AND *vascular injury, pulseless hand* AND *pediatric supracondylar humeral fracture, complex fractures* AND *pediatric supracondylar, compartment syndrome* AND *pediatric supracondylar humeral fracture humeral fractures*. To focus the search, the Boolean operator AND was used as appropriate.

Based on the information obtained, a bibliographic review of a total of 186 articles published in the PubMed, Hinari, SciELO and Medline databases was carried out using the EndNote search engine and reference manager. Of these, 32 selected citations were used to carry out the review that met the requirements for the review in terms of being current and related to the topic, all from the last 5 years, where 2 books were included.

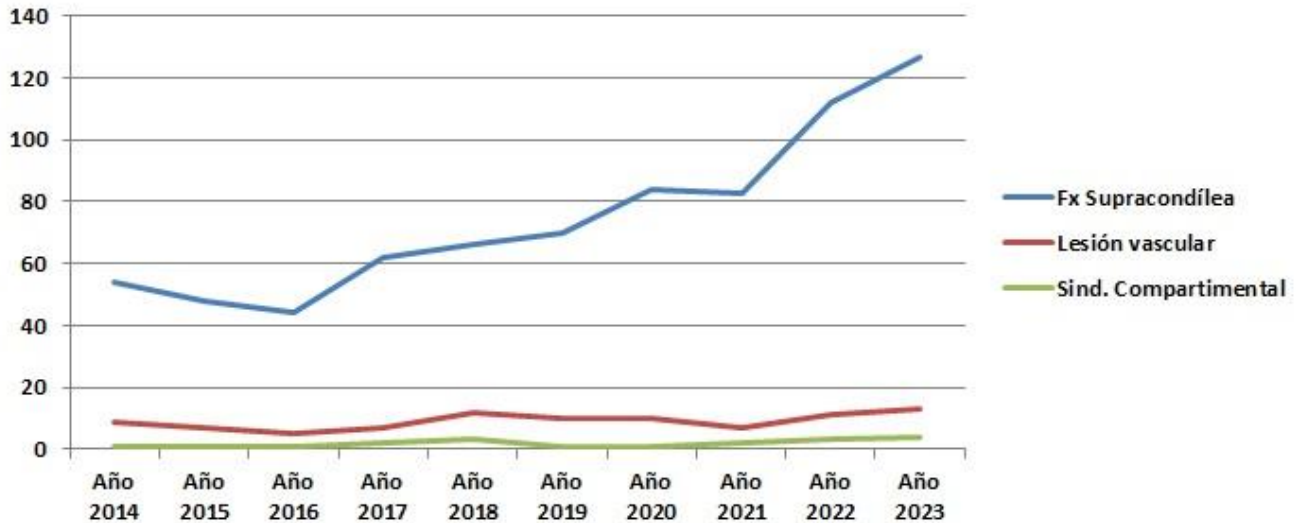


Review studies, books, case presentations and original articles from the databases described in the previous paragraph were considered. Research conducted in biomechanics laboratories was excluded. Bibliometric variables were used with PubMed as reference.

RESULTS

Although the incidence of vascular injuries in pediatric patients with supracondylar fractures of the humerus has decreased considerably in recent years due to the application of effective protocols in the prevention of this type of complications. There has been a relative increase in the number of articles in the PubMed database on this subject in the last 10 years (Figure 1).^(12,13)

Figure 1 Behavior of the number of articles in the PubMed database in the last 10 years.



Fuente: <https://pubmed.ncbi.nlm.nih.gov/>
Source: <https://pubmed.ncbi.nlm.nih.gov/>

Supracondylar Fx - Vascular Lesion - Compartment Synd.

The vascular evaluation of the extremity in pediatric patients with supracondylar fracture of the humerus with suspected vascular lesion is based on the exploration of the pulse and perfusion.^(14,15,16)

In relation to radial pulse alterations, they are characterized by: decrease, asymmetry and absence, each with different clinical interpretations. The damage of the artery can be of direct or indirect type. In the first group, the edges of the fractured bone lacerate the artery totally or partially, in the latter the intimal layer is affected, in addition the vasculonervous bundle is trapped within the fracture focus. On the other hand, compression is the main cause of indirect arterial damage.^(17,18,19)



For its part, the perfusion of the extremity is explored by color (pink or white), temperature (hot or cold) and capillary filling (normal or delayed).^(17,20)

Absence of radial pulse may be present in up to 20% of pediatric patients with displaced supracondylar fractures of the humerus, but only a small number require repair of the artery. The lesions of the artery are caused by incarceration of the neurovascular bundle at the fracture site, damage to the intimal layer with respective thrombus formation, partial or complete arterial laceration, pseudoaneurysms or compartment syndrome.^(21,22)

The location of the arterial damage, regardless of whether it is direct or indirect, is of great importance, since those occurring distal to the inferior ulnar collateral artery have a better prognosis, due to the rich circulation of the elbow that guarantees blood supply to the forearm and hand through this route (Figure 2).^(23,24)

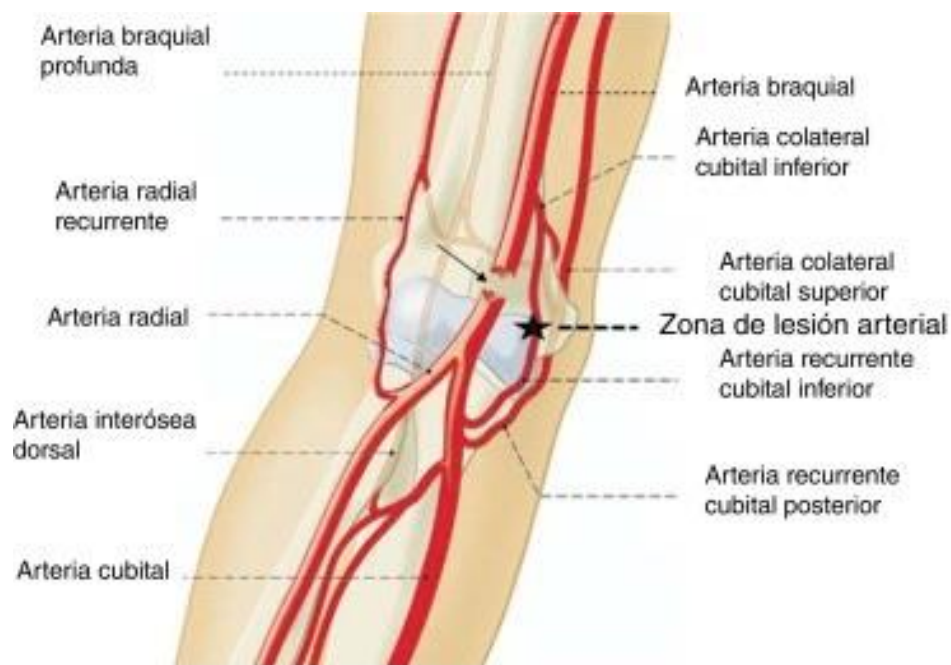


Figure 2: Anatomy related to the arterial supply of the elbow and location of the arterial lesion.

Taken and modified from: <http://e10.homes/fractura-supracond%3ADlea-arteria-braquial>

Deep brachial artery - Radial recurrent artery - Radial artery - Dorsal interosseous artery - Cubital artery

Brachial artery - Inferior cubital collateral artery - Superior cubital collateral artery - Arterial lesion zone - Inferior cubital recurrent artery - Posterior cubital recurrent artery

We must differentiate between two types of arterial lesions. The first is the absence of radial pulse with perfused, pink and warm hand. The other is the absence of radial pulse with decreased distal perfusion, pale and cold hand. In the first case the treatment is urgent and in the second is emergent. The first conduct in both cases is closed reduction of the fracture and percutaneous fixation with Kirschner wires.^(25,26)



Once the closed reduction and fixation with K-wire has been performed, if the extremity remains without radial pulse, but is well perfused, pink and warm, the patient is kept under observation until the pulse is restored. Otherwise it is justified to remove the wires and perform vascular examination of the area.^(27,28)

Arteriography or other vascular studies are not justified prior to closed reduction and fixation for two fundamental reasons, the first is that with reduction and fixation, vascularity is often restored, and the second is that the location of the arterial lesion after reduction remains unknown in the ischemic hand. Arteriography is considered an invasive procedure and has several risks in acute trauma such as: prolongation of the ischemia time between the moment the fracture occurs and the reduction, damage of the catheter to the vascular wall and contrast allergy. It is currently justified when symptoms and signs of ischemia persist 8 hours after fracture reduction and fixation.^(23,29)

Doppler ultrasound is a study that allows the evaluation of peripheral circulation even in the presence of edema of the extremity, by means of which asymmetry between the damaged extremity and the unaffected one is detected.^(9,23)

Magnetic resonance arthrography is a non-invasive procedure, which is more sensitive than arteriography in detecting peripheral circulation problems. This study is justified in pediatric patients with supracondylar fractures of the humerus with alterations of the pulse in which the Doppler examination is not conclusive.^(1,23)

The recommended approach in case of vascular exploration is the anterior approach, which can be extended proximally or distally according to the need of the lesion. This approach provides direct access to the neurovascular bundle and allows its repair if necessary. In the absence of partial or total laceration of the artery, a vascular spasm should be suspected, for which it is advisable to ensure the temperature of the limb and use papaverine and topical lidocaine. The indication of prophylactic fasciotomy in case of arterial injury is still under debate at present, some authors suggest performing this procedure if the ischemia time exceeds six hours.^(5,6,8)

Compartment syndrome in relation to pediatric patients with supracondylar fracture of the humerus has an incidence of 0.1 to 0.5%. Among the risk factors most commonly found with this complication are: older children, male sex, presence of floating elbow (the incidence increases to 33%), compression mechanism and associated neurovascular damage.^(30,31)

The clinical presentation of compartment syndrome differs in adults and children. In children, the 3A's should be taken into account: anxiety, agitation and increased analgesic needs. Particular care should be taken in patients with associated median nerve damage, as sensation of the volar compartment of the forearm is lost.^(21,32)



Measurement of the affected compartment is the test of choice in case of suspected compartment syndrome. This test is useful in these circumstances: uncooperative patients in whom an adequate vascular and nerve examination cannot be performed, patients who present entities such as head trauma or are under sedation who present swollen extremity and patients with previous neurological damage in whom differential diagnosis is difficult. The value of compartment pressure above 30 mmHg is considered an indication for immediate fasciotomy in adult patients, but not in pediatric patients who have higher compartment pressure.^(1,21,31)

The treatment of patients with suspected compartment syndrome is based on removing the immobilization and opening the elbow angle (removing flexion of the joint), and if the entity is established, the treatment consists of palmar fasciotomy of the forearm through an extensible approach from the elbow to the wrist. Ninety percent of patients who undergo fasciotomy an average of 30 hours after diagnosis have a good prognosis.^(31,32)

There are similarities and differences between compartment syndrome and arterial occlusion (Table 1).^(1,21,31)

Table 1 Clinical findings in compartment syndrome and arterial damage.

	<i>Compartment syndrome</i>	<i>Arterial occlusion</i>
Increased behavioral pressure	Increased	Normal
Pain on passive stretching	Augmented	Augmented
Paresthesia or anesthesia	Increased	Increased
Paresthesia or paralysis	Increased	Increased
Pulse	Intact	Affected

Fuente: Franz P⁽¹⁾, Tepper SC⁽²¹⁾, Toğaç S⁽³¹⁾

In addition to the clinical differences between these two entities, in the case of compartment syndrome there is elevation of enzymes such as creatine kinase due to muscle damage that triggers this condition, lactate dehydrogenase that is elevated in case of rhabdomyolysis as well as transaminases. The elevation of these enzymes helps to confirm the diagnosis of compartment syndrome.^(23,27)

CONCLUSIONS

Acute vascular complications related to supracondylar fractures in pediatric patients constitute a challenge for medical personnel. Their variants are multiple with different interpretation and behavior, most of the complementary examinations provide insufficient elements in the initial stages. Hence, the importance of a thorough physical examination at all times, to identify early these complications.



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Conflicts of interest:

The authors declare that there are no conflicts of interest.

Authors' contribution:

Alejandro Alvarez López: conceptualization, formal analysis, methodology, project management, software, monitoring, validation, writing - original draft, writing - review and editing.

Valentina Valdebenito-Aceitón: Conceptualization, data curation, research, project management, software, validation, visualization, writing - original draft, writing - review and editing.

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