

# Acute Compartment Syndrome of the Hand in a 14-Month-Old Child: A Case Report

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## Abstract

**Background:** Compartment syndrome is a well-known entity, but it is rare in the pediatric population, and its diagnosis is quite challenging. We report a case of an acute compartment syndrome (ACS) of the hand, developed after a crushing trauma, in a 14-month-old boy.

**Case Report:** A 14-month-old boy presented to the Emergency Department following a crushing trauma to his right hand. The patient had a progressive swelling of the right hand and agitation. On physical examination, the right hand was tense, swollen, with areas of skin necrosis and blisters, along with increased agitation upon palpation. Laboratory tests revealed elevated white blood cells (WBC), creatinine kinase (CPK), and erythrocyte sedimentation rate (ESR). Radiographic imaging showed deviated diaphyseal fractures in the second, third, fourth, and fifth metacarpals. A diagnosis of ACS of the hand was made. After draining the blisters, multiple fasciotomies were carried out to all 11 compartments of the hand. The metacarpal fractures were managed conservatively with a wrist splint for one month. A clinical and radiological follow-up after 7 months showed a complete functional recovery of the right hand and consolidation of the 2nd, 4th, and 5th metacarpal fractures, while the 3rd metacarpal fracture showed pseudoarthrosis.

**Conclusion:** Compartment syndrome of the hand in children is a rare condition, and its clinical picture may differ from that in adults, leading to a misdiagnosis or late diagnosis in many cases. Our case emphasizes the importance of a careful clinical evaluation in children post-trauma to diagnose such a condition.

**Keywords:** *Acute compartment syndrome; Hand; Trauma; Pediatric; Fasciotomy; Case report*

## Introduction

Acute Compartment Syndrome (ACS) was first described in 1881 by Volkmann during a hand contracture case, which was accompanied by increased intracompartmental pressure and microvascular compromise [1,2].

In children, ACS of the lower extremity was more prevalent than that of the upper extremities. Grottkau et al. showed that only 21% of patients presenting with ACS of the upper extremities were children with a mean age of 12 years [3]. Another study done by Broom et al. on young children (age<3) showed that the lower leg was the most common site for ACS (50%), followed by the hand, forearm, and elbow [4].

Besides trauma, the etiologies of ACS are diverse. These could include animal bites, hemorrhages, or in rare cases, hereditary angiomas, as reported in some case reports [5-7].

While the diagnosis of ACS could be made by physical evaluation solely and confirmed by intracompartmental pressure, the process could be complicated by several factors in the pediatric population [5]. Factors that may lead to a misdiagnosis in this patient population include the syndrome's different clinical presentation compared to adults, communication barriers between physician and child, and the difficulty of child cooperation with the physical examination [8].

The treatment of ACS in children is similar to adults and consists of urgent fasciotomy, and management of the underlying cause [5]. If left untreated, serious and long-term complications may occur, causing not only motor dysfunction of the limb but also systematic complications, such as renal impairment and myoglobinuria [5].

We hereby report a case of a 14-month-old boy that suffered a compartment syndrome of the hand following a crushing trauma.

## Case Presentation

A 14-month-old boy, previously healthy, presented to the Emergency Department 3 days after suffering a crushing trauma to his right hand by a scrap door. His parents noticed a progressive swelling of the right hand since the day of trauma, along with an increased agitation of the child, which did not improve with paracetamol.

Upon physical examination, the child was clinically stable but agitated, with a blood pressure of 100/70 mmHg and no fever. His right hand was swollen and tense. The palm was pale (Fig. 1), and there were two dorsal zones of skin necrosis and blister at the fingers and dorsal side of the hand (Fig. 2). The child's agitation increased upon passive stretching of the fingers.



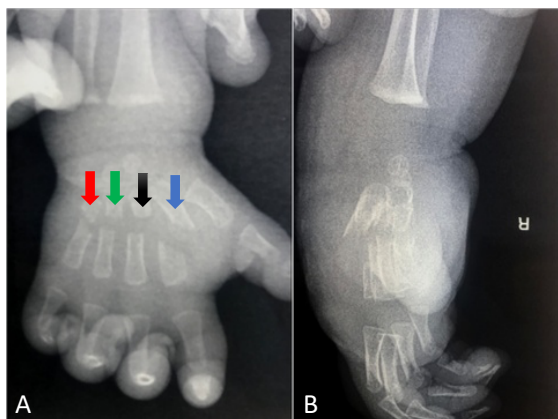
**Figure 1:** Picture showing the palmar side of the right hand, 3 days post-trauma. Note the pallor (arrow).

Laboratory tests revealed increased levels of WBC (20,000/mm<sup>3</sup>), CPK (520 mcg/l), and ESR (35 mm/hour). Renal function tests (creatinine and blood urea nitrogen) were within normal ranges. Urinalysis was normal, with no evidence of myoglobinuria.



**Figure 2:** Picture showing the dorsal side of the right hand, 3 days after trauma. Note the swelling of the right hand, small zones of necrosis on the dorsal side (white arrows), and blister formation at the fingers and dorsal side (red arrows).

Radiographic imaging showed diaphyseal fractures of the second, third, fourth, and fifth metacarpals with dorsal displacement and interfragmentary gap (Fig. 3). After clinical and radiological evaluation, the diagnosis of compartment syndrome of the right hand after a crushing trauma was made.



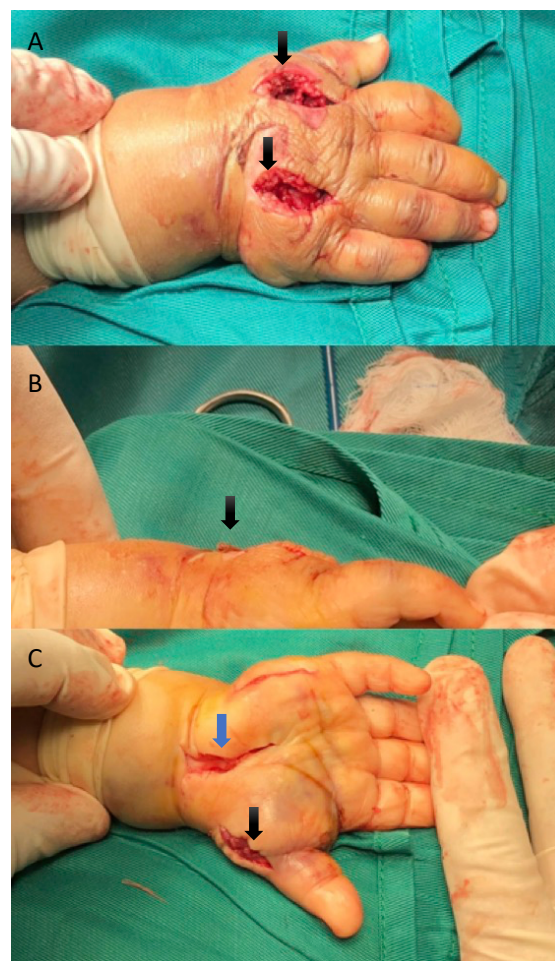
**Figure 3:** (A) Anteroposterior and (B) lateral radiographs of the right hand, at the time of presentation, showing diaphyseal fractures of the second (blue arrow), third (black arrow), fourth (green arrow), and fifth metacarpals (red arrow), with dorsal displacement and interfragmentary gap.

After draining the blisters, multiple fasciotomies were carried out to the hand compartments. After general anesthesia, the fasciotomies were done by five different incisions: two dorsal incisions of the hand in line with the 2nd and 4th metacarpals to release the dorsal, volar interosseal, and the adductor pollicis compartments; an incision along the radial aspect of the 1st metacarpal to release the thenar compartment; an incision along the ulnar aspect of the 5th metacarpal to release the hypothenar compartment; and an anterior midline incision to release the midpalmar compartment (Fig. 4A-C).

The surgery was completed without any intra- or postoperative complications. Metacarpal fractures were managed conservatively by a wrist splint for one month. The patient was discharged after 24 hours.

A clinical and radiological follow-up seven months after discharge showed a complete functional recovery of the right

hand, and consolidation of the 2nd, 4th, and 5th metacarpal fractures, while the 3rd metacarpal fracture showed pseudoarthrosis (Fig. 5, 6).



**Figure 4:** Gross pictures taken during surgery showing (A) the 2 dorsal incisions in line with the 2nd and 4th metacarpals (arrows) (B) the incision made along the ulnar aspect of the 5th metacarpal (arrow) and (C) the incision made along the radial aspect of the 1st metacarpal (black arrow), and along the anterior midline (blue arrow)



**Figure 5:** Picture of the right hand taken 7 months after initial presentation, showing a good wound healing and a good hand grip





**Figure 6:** (A) Anteroposterior and (B) Lateral radiographic images of the right hand, 7 months since the first presentation, showing the consolidation of the 2nd, 4th, and 5th metacarpals. The 3rd meta-carpal shows evidence of pseudoarthrosis (arrow)

### Discussion

The etiologies of ACS in children are numerous (Table 1); however, they could vary significantly based on the age group [5-7]. In general, trauma or surgical positioning are the usual causes in children above 14 years of age. In children less than 10 years old, the causes are usually infection and vascular injury [8]. According to the study done by Broom et al., the primary cause in children was trauma (60%), followed by infection (27%), and intravenous infiltration (13%) [4].

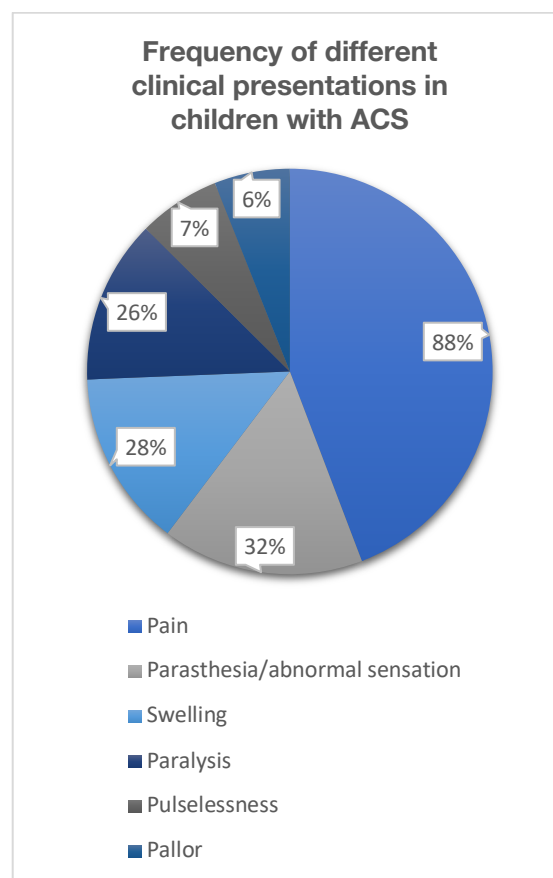
**Table 1:** Causes of ACS in children

Causes of ACS in Children
Trauma
Septicemia
Bleeding or clotting disorders
Animal bites
Prolonged vascular reconstruction
Fluid infiltration
Hereditary angioedema

ACS could be mainly attributed to two physiologic changes at the level of the compartment including increased content, decreased volume, or both simultaneously. This causes an increase in the intracompartmental pressure exceeding the venous capillary pressure and thus

increasing the hydrostatic and venous capillary end pressures and compressing the arterioles. This causes a microvascular disturbance, decreasing the tissue perfusion and leading to muscle ischemia [9]. Ischemia causes leakage, which continues despite reperfusion, leading to further increase in hydrostatic and intracompartmental pressures, thus forming a vicious cycle [10].

The clinical picture of ACS in children may have different presentations. A meta-analysis done by Samora et al. showed that, among 165 children diagnosed with ACS, the most common presentation was pain. Other presenting symptoms were paresthesias/abnormal sensations, swelling, paralysis, pulselessness, and pallor [11]. You can find the distribution of these clinical pictures among the patients in Figure 7. Pain, however, has shown to be an unreliable symptom, having a sensitivity of 54% for diagnosing ACS in children [4].



**Figure 7:** Pie chart showing the frequency of different clinical presentations in children with ACS [11]

The diagnosis of ACS in children differs from that in adults. In a study done by Bae et al., involving 36 cases of children with ACS, it was shown that the classical 5P's (pain, pallor, pulselessness, paresthesia, paralysis) used in diagnosing ACS in adults were unreliable in the pediatric population [12]. McCarthy and Noonan stressed instead on using the 3A's (agitation, anxiety, increasing analgesic requirements) as the diagnostic criteria [5]. In our case, the child was brought 3 days after noticing an increased agitation and swelling, which were not improved with paracetamol. The history and physical examination were not completely applicable due to the communication barrier and absence of cooperation. Based on our clinical evaluation, we made the diagnosis of ACS.

Although the diagnosis of ACS is clinical, measuring intracompartmental pressure could be valuable in noncommunicative patients or cases of uncertain diagnosis. However, this will often require conscious sedation of the child [8]. There are two ways to identify an elevated intracompartmental pressure; the first way is to directly measure the compartment pressure using an intracompartmental pressure monitor or arterial line transducer system [13]. A pressure > 30 mmHg confirms compartment syndrome. The second way is to calculate the difference between the compartment pressure and the patient's diastolic pressure. If the difference is < 30 mmHg, then the diagnosis of compartment syndrome is made. However, these values were derived from adults and do not apply to pediatric patients without further studies [13].

Other non-invasive methods are on the rise to replace traditional invasive intracompartmental pressure monitoring, which could aid physicians to diagnose ACS with higher accuracy.

One of these methods is the Near-Infrared Spectroscopy, which is a device that continuously measures tissue oxygenation. Significantly low tissue oxygenation indicates the occurrence of compartment syndrome, and this was

especially evident in a study done by Giannotti et al. on patients with ACS. The pre-fasciotomy mean tissue oxygen saturation (StO<sub>2</sub>) in the leg compartment with the highest pressure was  $56 \pm 27\%$ , compared to the post-fasciotomy mean StO<sub>2</sub>, which was  $82 \pm 16\%$  [14].

Another non-invasive method relies on ultrasound. In a study by Marmor et al. on leg cadavers, the authors showed a strong correlation between ultrasound measurements and the pressure sensing transducer [15].

As in adults, the management of ACS in the pediatric population is urgent fasciotomy. Since the measurement of compartment pressure is not always feasible, the decision to do fasciotomy often depends on clinical judgment [16]. External sources of compression, like casting, should be removed and the affected limb should be maintained at the level of the heart.

The hand is composed of 11 compartments: 3 volar interosseal compartments, 4 dorsal interosseal compartments, a hypothenar compartment, a thenar compartment, a midpalm compartment, and an adductor compartment. Fasciotomy of the hand usually involves multiple incisions for all compartments [2].

Although fasciotomy is an urgent procedure, there is a debate whether fasciotomy should be done regardless of the time of presentation post-injury. In a study done by Finkstein et al., patients who presented after 36 hours post-injury suffered long term complications due to infection and septicemia. Hence, they recommended to reassess the decision of performing fasciotomies in patients presenting after 8-10 hours post-injury [17]. However, in our case, no complications were noted after a clinical and radiological follow-up, except for pseudoarthrosis at the 3rd metacarpal.

Whitesides and Heckman stated that ischemia of 8 hours duration causes a permanent damage to the nerves and

muscles [18]. However this is not always applicable in the pediatric population. In the meta-analysis done by Samora et al., it was concluded that the mean time from injury to fasciotomy was 25.4 hours. Despite that, 88% of the children had full functional recovery. This could be explained by the more resilient muscles in children, or by the unknown exact time of ACS onset following injury [11].

Our case was limited by the establishment of the diagnosis based on physical examination, laboratory testing, and radiographic imaging, without measuring intracompartmental pressures due to the unavailability of the necessary equipment.

### Conclusion

Compartment Syndrome of the hand is a rare condition in the younger population in whom the clinical picture differs from that of adults, thus increasing the risk of late or misdiagnosis. Therefore, a careful clinical evaluation is indispensable for the diagnosis and management to avoid serious and long-term complications, especially muscle and nerve necrosis.

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