CASE REPORT

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Early Explorative Decompression for Suspected Compartment Syndrome of the Hand after Closed Metacarpal fracture in a child- A Case Report and literature review

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Abstract

Multiple fractures of the hand can lead to compartment syndrome [1,2]. Unlike adults, young children are unable to communicate or express the exact source of their pain, making the diagnosis of compartment syndrome in the hand even more difficult in this patient population. Surgeons should therefore have a high index of suspicion in these children and consider performing early prophylactic compartment release to prevent the sequalae of ischaemia, which can lead to necrosis of the small muscles of the hand. Although compartment syndrome and its associated injuries and complications have been well described in adults, there has been less study of compartment syndrome in children. We present a case report of a 23-month-old child who presented with closed fracture of the 2nd, 3rd, 4th and 5th metacarpal base that required fixation. Compartment syndrome was suspected in the patient and early exploration was performed, which resulted in good functional outcome and recovery postoperatively. A literature review of compartment syndrome of the hand in children is also presented.

Keywords: Metacarpal fracture, Hand fracture, X-ray.

INTRODUCTION

The most frequently injured part of the body in a child has been said to be the hand [3]. Metacarpal fractures makes up to around 10-39% of all paediatric hand fractures, especially in the 13- to 16-year old age group [4,5]. It most commonly involves the 5th metacarpal neck. Fractures of metacarpal shafts are much less common [6], with the incidence evenly distributed in the 3rd, 4th and 5th metacarpal, whilst the 2nd metacarpal involvement being relatively rare [5].

Severe crush injuries are usually thought to be associated with poor functional outcome and prognosis [7]. However, a 5-year

retrospective review study concluded that crush injury does not in itself carry a poor functional prognosis, provided that attention is paid to any concomitant compartment syndrome [7]. The study also found that the incidence of acute compartment syndrome of the hand may be higher than that expected from the literature [7], maybe due to some occult, unrecognized cases. Therefore, early diagnosis and prompt treatment of acute compartment syndrome is crucial in the prevention of adverse devastating outcome. This would require an early and accurate recognition of the clinical signs and symptoms of acute compartment syndrome in the paediatric patients. However, as opposed to the adult population, young children are often unable to communicate or clearly express the exact source of their pain, making the diagnosis of compartment syndrome in the hand even more difficult in this patient population. In contrast to acute compartment syndrome in adults, there is less study about acute compartment syndrome in the paediatric population.

We would like to present a case of closed fracture of the 2nd, 3rd, 4th and 5th metacarpal base after a crush injury to the hand. We performed an early surgical exploration and decompression with internal fixation of the fracture, based on a high index of clinical suspicion for compartment syndrome. This resulted in a prompt and good functional recovery of the patient.

CASE REPORT

A 23-month-old boy with good past health was admitted for left hand pain and swelling following a crush injury by a fallen heavy porcelain sink. He complained of acute left-hand pain and swelling afterwards. Physical exam showed bruising and swelling over the whole palm. There was no open wound. There was diffuse tenderness on palpation of the left hand. Radial pulse was strong. Capillary refill of all fingers were within 2 seconds. X-ray showed long oblique facture over 2nd, 3rd metacarpal shaft and transverse fracture over 4th, 5th metacarpal base. Computed Tomography scan was also performed, and showed oblique shaft fractures of 2nd and 3rd metacarpal bone with ~27 degrees of volar angulation and ~4mm displacement, and transverse fracture of 4th and 5th metacarpal base with ~3mm bony displacement. (Fig 1). In view of the increasing requirement of analgesics and marked progressive swelling of the hand, acute compartment syndrome was suspected. An emergency operation with explorative incision was performed, K-wire fixation to 2nd,3th metacarpal fracture and intraosseous suture of base of 4th, 5th metacarpal bone was also done. Intra-operatively, all compartments were found to be swollen, but not tense. There was oblique unstable radially translated fracture at the proximal shaft of 2nd, 3rd metacarpal bone, extra-articular fracture of the metaphyses of 4th metacarpal bone and unstable intra-articular fracture of 5th metacarpal base with radial fragment (involving 50% of articular surface). Post-operatively, the patient's hand swelling and fingers range of motion gradually improved and patient was discharged on post-operative day 5. All K wires were removed in the 5th week post-operation. At the 10th-month post-operative visit, all wounds healed well. There was no malrotation of fingers clinically and radiogically (Fig.2, 3). The active range of motion of flexion of 2nd metacarpo-phalangeal joint (MCPJ) was around 70degrees, passive range up to 80 degrees.

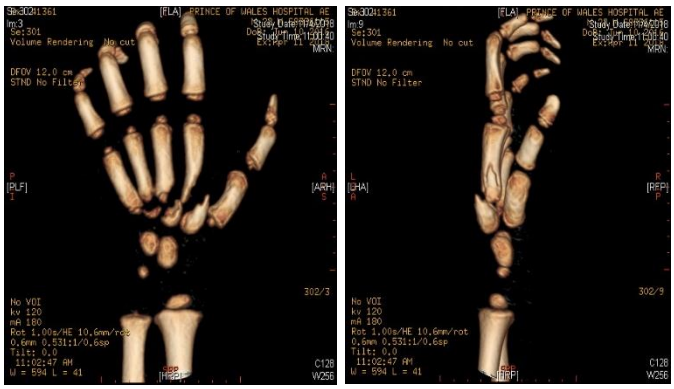

Fig 1: Computed Tomography image

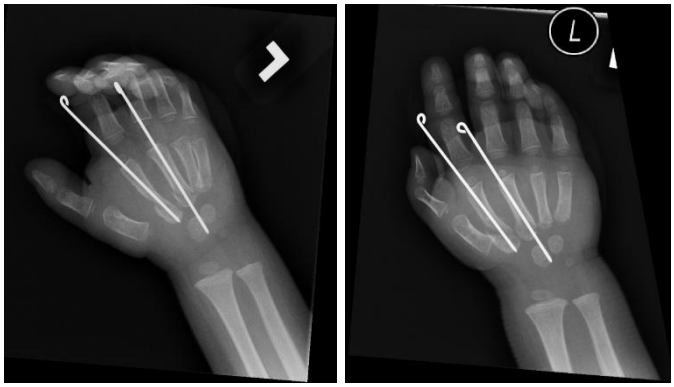

Fig 2: X-ray image at 2-weeks post-operation, showing the position of K wires and the fracture fixation

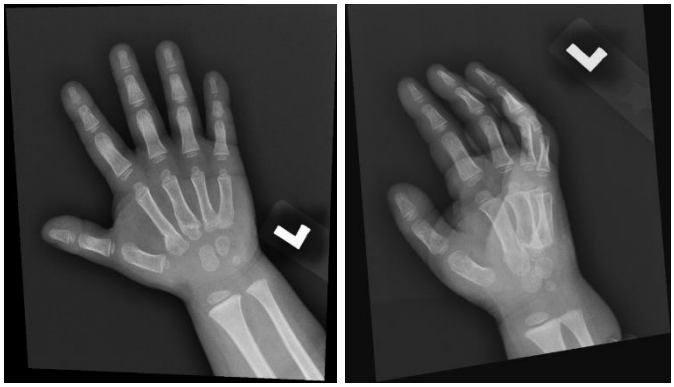

Fig 3: X-ray image at 10th month post-operation, showing fracture consolidated and healed with good alignment

DISCUSSION

There are 10 compartments in the hand in total, including thenar, hypothenar, adductor, four dorsal interosseous and three volar interosseous compartments. Acute compartment syndrome occurs when the interstitial pressure within a confined fascial space increases to a level that decreases the perfusion gradient across tissue capillary beds, leading to a compromise in circulation and hence resulting in tissue ischemia. Compartment syndrome can result in muscle ischaemia and contracture and even nerve paralysis. Although carpal tunnel is not a myofascial compartment, the median nerve is also susceptible to compression.

The diagnosis of acute compartment syndrome is largely clinical. Therefore, clinicians should always be alert of the possibility of acute compartment syndrome when evaluating patients with an acute closed fracture with intense pain and swelling. Studies have shown that palpation of the compartments of the hand clinically has low sensitivity and specificity in diagnosing high pressures [8]. Classical clinical signs such as pain, pallor, paraesthesia, paralysis and pulselessness were inconsistent indicators of impending compartment syndrome [9]. Paralysis and pulselessness are very late signs that already signifies irreversible tissue damage. Compartment syndrome is often present despite the presence of a pulse. One has to bear in mind that the absence of the 5 “P”s does not rule out compartment syndrome out, but rather a more useful feature for evaluating presence of vascular injury, rather than compartment syndrome itself. The most sensitive clinical sign is pain with passive motion at the MCPJ [10]. Moreover, in a trauma setting, pain is often difficult to differentiate from the injury itself. Therefore, an increasing analgesia requirement, signifying disproportionate pain, in combination with other clinical signs was a more sensitive indicator of compartment syndrome [9]. Acute hand compartment syndrome can also present with intrinsic minus posturing, characterized by MCP hyperextension with PIPJ and DIPJ flexion, caused by imbalance between strong extrinsics and deficient intrinsics muscles [11].

Compartment syndrome is said to exist when the compartmental pressure is 20 to 30 mmHg below diastolic pressure, according to Matava in an animal studies.10 There are various techniques and devices mentioned in the literature for measuring the intracompartment pressure (ICP), for example hand-held monitor for single pressure readings, such as Stryker needle with side portal, and regular needle with arterial line setup, or a simple three-way stopcock system involving an intravenous tubing, a syringe, and a mercury manometer, as described by Whitesides *et al* [12]. However, the measurement of ICP for diagnosis of acute compartment syndrome in an awake patient is controversial. Different authors mentioned different values of compartment pressure to be the threshold for consideration of surgical decompressive fasciotomy and also reported their clinical outcome [13,14]. McQueen *et al*. reported in a retrospective study 93% sensitivity of ICP monitoring in suspected acute compartment syndrome (ACS) with an estimated specificity of 98%, an estimated positive predictive value of 93%, and an estimated negative predictive value of 99% [15]. While Whitney et al. mentioned 35% false-positive rate for the diagnosis of ACS in patients with tibial shaft fractures on one time ICP measurement under anaesthesia prior to fixation of tibial fractures, clinically they did not have any clinical evidence of compartment syndrome pre- and postoperatively and fasciotomy was not performed [16]. Therefore, continuous ICP monitoring rather than one-time single measurement is recommended for establishing diagnosis of acute compartment syndrome.

Muscles can tolerate up to 4 hours of ischemia well, but by 6 hours the result is uncertain, and after 8 hours, the damage is irreversible [17]. Ischemic injury begins when tissue pressure is 10 to 20 mmHg below diastolic pressure [17]. Some studies have also shown that the mean compartment pressure in children was higher than that in adults [18,19]. In general, it is widely accepted that pressures over 30 mmHg or within 30 mmHg of the diastolic blood pressure in adults warrant an emergent evaluation for a possible fasciotomy and limb salvage [20]. They believe that the diastolic blood pressure is a key determining factor. According to that theory, a patient with a higher diastolic blood pressure would more likely tolerate a higher absolute compartment pressure than a hypotensive patient. Children have a physiologically lower diastolic blood pressure than adults, resulting in a lower perfusion gradient with a given compartment pressure. Therefore, one may speculate that fasciotomy should be performed at lower compartment pressures in children than in adults. However, a prospective study that compares the compartment pressures in children with normal un-injured forearm and those with fracture but without clinical suspicion of compartment syndrome revealed that some children with forearm fractures tolerated absolute compartment pressures >30 mmHg without any clinical signs of acute

compartment syndrome [18]. Hence emergency fasciotomy could possibly be delayed or even avoided in that group of patients. Therefore, we could not rely too much on the reading of the intracompartment pressure in the diagnosis of acute compartment syndrome and the decision on decompressive fasciotomy. This may be due to the different methods of measurement of compartment pressure between studies and also the normal intracompartment pressure can vary greatly between different individuals.

In the setting of an acute hand compartment syndrome, it is often necessary to make multiple incisions to facilitate access to all areas while performing emergency decompressive fasciotomy [21]. The most common approach involves two longitudinal dorsal incisions, to release the interossei, and a thenar eminence incision +/- a carpal tunnel release [20,21]. However, an anatomical study using a gelatin injection method in 21 cadaver hands showed that the thenar space comprises 2 or more discrete compartments in 52% of the hands, and the hypothenar space demonstrated at least 2 compartments in 76% of the hands [22]. Therefore, subcompartmentalization of the enclosed myofascial spaces of the hand should be considered in cases requiring fasciotomy.

Although not as common as compartment syndromes of the forearm and leg, compartment syndrome of the hand is not rare. Effective treatment of a compartment syndrome requires early recognition of its signs and symptoms and early surgical intervention to avoid disastrous complications, which will result in devastating functional loss to the patient. Although compartment syndrome and its associated injuries and complications have been well described in adults, there has been less study of compartment syndrome in children.

The diagnosis of compartment syndrome is often difficult to make in the paediatric population, who often may not have the cognitive or verbal ability to provide relevant clinical information during examination. Unusual or disproportionate pain may be the only symptom of an impending compartment syndrome, hence clinicians should always maintain a high index of suspicion and a low threshold for consideration of early explorative decompressive surgery, in order to prevent irreversible tissue necrosis, ischemic contracture, nerve paralysis, functional loss or even amputation.

Pain, pallor, paresthesia, paralysis, and pulselessness are often unreliable indicators of compartment syndrome, which may present only after irreversible tissue damage has already occurred. Persistent restlessness, agitation or anxiety, with an increasing analgesic requirement, may be other indicators of an impending or established compartment syndrome in children, although these signs are difficult to quantify and have been inadequately studied [23]. Compartment pressure measurement is currently the most objective method and an essential tool that can aid the diagnosis of compartment syndrome, with varying reports regarding the different critical threshold parameters and their relationship to ultimate clinical outcome [13,14]. We advocate adopting a lower threshold for critical compartment pressure.

CONCLUSION

In conclusion, there is no single best method for diagnosing acute compartment syndrome in children in the current literature. Moreover, a high clinical suspicion and physical examination are still the most important criteria for diagnosing acute compartment syndrome in the paediatrics population. Therefore, serial physical examinations are recommended and, if in doubt, interstitial compartment pressure measurement and monitoring is indicated. It is well-recognised that early recognition of acute compartment syndrome and hence early treatment will lead to a good return of hand function.

Conflict of Interest

The authors declare that there is no conflict of interest.

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