Delaying treatment of supracondylar fractures in children

HAS THE PENDULUM SWUNG TOO FAR?

The aim of this retrospective multicentre study was to report the continued occurrence of compartment syndrome secondary to paediatric supracondylar humeral fractures in the period 1995 to 2005. The inclusion criteria were children with a closed, low-energy supracondylar fracture with no associated fractures or vascular compromise, who subsequently developed compartment syndrome. There were 11 patients (seven girls and four boys) identified from eight hospitals in three countries. Ten patients with severe elbow swelling documented at presentation had a mean delay before surgery of 22 hours (6 to 64). One patient without severe swelling documented at presentation suffered arterial entrapment following reduction, with a subsequent compartment syndrome requiring fasciotomy 25 hours after the index procedure.

This series is noteworthy, as all patients had low-energy injuries and presented with an intact radial pulse. Significant swelling at presentation and delay in fracture reduction may be important warning signs for the development of a compartment syndrome in children with supracondylar fractures of the humerus.

Supracondylar fractures comprise between 3% and 18% of paediatric fractures and 60% of paediatric fractures about the elbow.\(^1\)\(^2\) The incidence of compartment syndrome is estimated to be 0.1% to 0.3%, and can be a devastating complication of these fractures that requires urgent fasciotomy.\(^3\) Soft-tissue reconstructive procedures may be needed if an ischaemic contracture develops.\(^4\)

There have been few reports of established compartment syndrome following paediatric supracondylar humeral fractures. Lipscomb\(^5\) reported two patients with established ischaemia following supracondylar humeral fracture treated by fasciotomy and stripping of the sympathetic nerve fibres of the ulnar, radial and brachial arteries. Mubarak and Carroll\(^4\) reported nine cases of compartment syndrome secondary to extension-type supracondylar fractures presenting to the Hospital for Sick Children in Toronto over a 20-year period. The volar compartment of the forearm was involved in all cases, resulting in ischaemic contracture. Eight cases were thought to be the result of elbow flexion to more than 90° following closed reduction. Arterial exploration and fasciotomy was performed in two patients and the outcome was poor in seven of the nine cases. Only one case of compartment syndrome was diagnosed within six hours of injury, in the other eight there was a delay in diagnosis of more than 24 hours. No further details were given, such as the status of the radial pulse or the Gartland fracture classification\(^6\) on presentation.

Modern treatment methods, improved recognition and prevention of compartment syndrome have apparently resulted in fewer cases being reported in the literature.\(^7\)\(^8\) Four recent retrospective studies reported no case of compartment syndrome or other adverse events associated with a mean delay of six to 21 hours in the treatment of paediatric supracondylar humeral fractures.\(^9\)\(^12\) Mehlm\(\text{a}\) et al\(^10\) found that a delay of eight hours did not increase the rate of compartment syndrome in Gartland II and III supracondylar humerus fractures. Iyengar et al\(^10\) confirmed this finding in Gartland type II fractures with a delay of more than eight hours, whereas Leet et al\(^11\) showed no increased risk with a delay of 21.3 hours in Gartland type III fractures. Most recently, Gupta et al\(^12\) reported no increased risk in a series of 100 patients with Gartland II and III fractures who underwent surgery more than 12 hours after injury. However, these studies agree that a delay in treatment is not advisable for patients with a progressive neurological deficit or an absent pulse on presentation.

The good results in these studies may, in part, be due to the bias of experienced paediatric...
orthopaedic surgeons selecting which fractures required urgent treatment. With this emphasis on the non-emergency treatment of these injuries, we hypothesised that compartment syndrome may continue to occur despite modern fracture treatment methods. The aim of this retrospective study was to identify cases of compartment syndrome occurring in association with supracondylar humeral fractures in children without associated risk factors, such as vascular compromise, ipsilateral fractures or a high-energy mechanism of injury, and to look for common factors that may aid predicting those at risk.

**Patients and Methods**

The design of this study was reviewed and approved by the Research and Development Directorate of the primary institution. Because the study design is a retrospective case series, with anonymised clinical data reported by participating centres, ethical committee approval at the primary institution was not required and hence not sought. We contacted over 50 paediatric orthopaedic surgeons in the United States, United Kingdom, Australia, and New Zealand to identify cases of established compartment syndrome in conjunction with paediatric supracondylar humeral fractures that had presented between 1995 and 2005 at their institutions. The inclusion criteria were children with a closed supracondylar fracture with no associated fractures, a low-energy injury, and a palpable radial pulse that went on to develop a compartment syndrome.

A total of 11 patients were identified presenting to eight hospitals in three countries (United States, United Kingdom and New Zealand). The participating surgeons completed data sheets based on a retrospective review of medical records and returned them to the primary institution. Patient age, gender, date and time of injury, time to first presentation, clinical and radiological findings at presentation as recorded by the admitting orthopaedic resident/specialist registrar, time from injury to the initial surgical procedure, and details of the initial procedure were recorded. Specifically on the clinical examination, the radial pulse was classified as one of four types: 2+ (palpable and strong), 1+ (weak but palpable), absent, or unknown (if records were insufficient). Use of a Doppler probe to identify the radial pulse was inconsistent and inadequately recorded in the available records, and was therefore not used to classify the radial pulse. Associated injuries to specific nerves at the time of presentation were also recorded. Fractures were classified on initial radiographs according to the Gartland classification.

Following the initial surgical procedure, the postoperative progress, time to diagnosis of compartment syndrome (from injury or initial surgery), immediate treatment, any further surgical procedures and outcome were also noted. The final outcome was graded according to the resulting functional deficit in each limb as defined by Mubarak and Carroll. Limbs with marked sensory and motor loss and contracture were rated severe. Limbs with digital hypoaesthesia, intrinsic paralysis, and contracture of the muscles of only the deep compartment were graded moderate. Limbs with only slight intrinsic contracture and intact motor and sensory function were graded as mild.

Of the 11 patients there were seven girls and four boys, with a mean age of 6.8 years (3.4 to 14.7). There were ten extension-type injuries (nine Gartland type III fractures and one Gartland type II) and one flexion type injury. All were low-energy injuries (e.g. a fall from a short distance, such as less than four steps or stairs). The mean length of follow-up was 5.2 years (1.5 to 8.2).

**Results**

Data relating to the patients prior to and following their initial surgical procedure are provided in Tables I and II. The mean length of time between injury and presentation to the treating hospital was 6.3 hours (2 to 16). The radial pulse was present and palpable in all patients on presentation (2+ in five and 1+ in six). Capillary refill was normal (< 2 seconds) in all patients on presentation.

Severe swelling of the elbow was documented at presentation in ten patients. The mean delay until surgery for these patients was 22 hours (6 to 64). Clinically, ecchymosis was documented at presentation in seven patients and soft-tissue puckering was noted in two. With respect to nerve injuries on presentation, seven patients had sensory changes, in the distribution of the median nerve in three, ulnar in two and radial in two.

Of the 11 patients, ten were treated at the tertiary hospital by reduction and percutaneous pinning, followed by casting of the elbow in less than 90° flexion. One (patient 2), had a Gartland III fracture with a strong radial pulse preoperatively and was treated by closed reduction without pinning and casting of the elbow at the primary referring hospital. In this patient, there was also a delay in diagnosis of the compartment syndrome of 12 hours even though the radial pulse had disappeared post-operatively and she had complained of severe pain requiring opiate analgesia.

Fasciotomy was performed at the initial operative reduction in three patients. In two (patients 4 and 5) this was because of a tense volar compartment on palpation at surgery, and in the third (patient 9), the intra-operative pressure was 78 mmHg in the superficial volar compartment and 95 mmHg in the deep compartment. Normal compartment pressures were documented in one (patient 7) at the index procedure. In six patients fasciotomy was undertaken after the initial operative reduction. The mean delay to diagnosis of compartment syndrome following the index procedure in these six cases was 14.5 hours (6 to 25), although signs and symptoms were present early in the clinical course. Two patients did not undergo a fasciotomy, as they presented with established ischaemic contracture, one at two weeks and the other at three weeks following operative stabilisation.

Only one (patient 1) presented without severe swelling (and no associated ecchymosis). This patient had a delay...
before surgery of 16 hours and sustained arterial entrapment following initial operative stabilisation of her Gartland III injury, which required subsequent exploration and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotomy and freeing of the brachial artery. The radial pulse was not palpable immediately post-operatively. Fasciotom...
We believe this to be the largest series of compartment syndrome following paediatric supracondylar fractures of the humerus. It is particularly noteworthy that all the patients presented with a palpable radial pulse, following a low-energy injury and with no associated fractures. It has been shown that there is an increased risk of vascular injury in association with a high-energy mechanism of injury, ecchymosis in the antecubital fossa secondary to partial disruption of the brachialis muscle, and posterolateral displacement of the distal fracture fragment on radiographs.\textsuperscript{19-22} In our series, ecchymosis was documented at presentation in seven of 11 patients, suggesting that this clinical sign may be of use in predicting a limb at risk of ischaemia. Furthermore, seven patients had documented sensory changes in one or more of the median, radial and ulnar nerves at presentation. A neurological deficit on presentation is a sign of significant associated soft-tissue injury, and in these patients, in combination with other signs such as ecchymosis, may constitute a red flag of warning for the development of a compartment syndrome.

A limitation of this study is the subjective nature of the term ‘severe swelling’. However, the fact that ten of 11 patients were recorded as having severe swelling at presentation is noteworthy. We feel that severe elbow swelling (with or without ecchymosis) should alert the clinician to a high index of suspicion for the possibility of compartment syndrome, particularly when there has been a delay in reduction of the fracture. In future, clinicians could consider measuring the degree of elbow swelling objectively by, for example, measuring the maximum circumference of the elbow and recording it as a ratio in comparison with the normal contralateral limb, or by measuring soft-tissue swelling on radiographs. Such objective evidence may help predict those limbs at risk of compartment syndrome.

Several series emphasise the importance of an absent or diminished radial pulse and the need for close monitoring for the subsequent development of compartment syndrome.\textsuperscript{5,8,23} In a series of 128 consecutive children with Gartland III supracondylar humeral fractures reported by
Copley et al., 17 had an absent or diminished pulse, of which 14 recovered after operative reduction and stabilisation. Subsequently, two of these had post-operative deterioration in their vascular status and required exploration and bypass arterial grafting after diagnostic arteriography. One of these required fasciectomy and subsequently developed an ischaemic contracture. The remaining three with persistent absence of the radial pulse after initial stabilisation were explored immediately and found to have a significant brachial artery injury that required repair. The authors concluded that the sensitivity of an absent or diminished radial pulse on presentation was 100% for detecting vascular injuries. In this study, no comment was made on the degree of elbow flexion used to immobilise these fractures after pinning. However, others have questioned the absence of a pulse as a danger sign as its presence is not a guarantee that ischaemia will be avoided.24,25 In our series, all patients presented with a palpable radial pulse. Two had changes in the radial pulse following their initial intervention. In one (patient 1), who presented without severe swelling or ecchymosis, arterial entrapment occurred at the initial operative stabilisation and the radial pulse was lost in the immediate post-operative period. Although the hand remained pink post-operatively, the disappearance of the radial pulse in a child who had a radial pulse preoperatively should have alerted the treating clinicians to an intra-operative arterial injury.

In the second patient (patient 2), excessive elbow flexion in an unpinned Gartland III fracture may have contributed to the development of a compartment syndrome. This patient highlights the concept that operative stabilisation with pinning would have allowed the elbow to be placed in less than 90° of flexion post-operatively, thereby reducing the pressure on the anterior vascular structures. Although historically, hyperflexion up to 120° has been recommended to maintain reduction in unpinned Gartland II fractures, Skaggs and Flynn26 recommended that if an elbow needs to be held in more than 90° of flexion to keep the fracture reduced, using K-wires to maintain the reduction is probably safer. Pirone, Graham and Krajibich27 reported one case of ischaemic contracture caused by excessive flexion of the elbow in a cast after closed reduction without pinning. Mapes and Hennrikus,28 in a prospective study of 20 patients with Gartland II and III fractures who had undergone closed reduction and pinning, showed that the radial pulse was ablated with excessive flexion in combination with pronation. Battaglia et al3 measured post-reduction compartment pressures in 29 children with Gartland II and III fractures and showed that elbow flexion beyond 90° produced significant pressure elevation in the deep volar compartment. At 120° of flexion, the average pressures were nearly 35 mmHg greater than at 90°, with no significant differences between 0°, 40° and 90°. Operative reduction and pinning is the standard treatment for Gartland III fractures. Pinning may be preferred to obviate the need to immobilise the elbow in more than 90°, as demonstrated by patient 2 in this series. Because of the risk of ischaemia, most authors now recommend that hyperflexion of the elbow should be avoided after operative fixation. For example, after pinning, Rang29 recommended extending the arm to approximately 70° and applying a light padded cast. Shaw et al30 recommended that, after closed reduction and pinning, the elbow should be positioned in 60° of flexion in a posterior splint.

A further contributing factor to compartment syndrome in both patients with post-operative changes in the radial pulse (patients 1 and 2) could have been an ischaemia-reperfusion injury following correction of the initial vascular deficit. Reperfusion after treatment for arterial obstruction is a well-known cause of compartment syndrome. The reperfusion syndrome consists of a local response with limb swelling, an associated inflammatory response and a possible systemic response, resulting in skeletal myonecrosis (occurring between three to six hours after reperfusion).31 Various treatments have been studied in small- and large-animal compartment syndrome models in an attempt to reduce the skeletal muscle injury during reperfusion, such as oral vitamin C,32 dichloroacetate33 and selective type III phosphodiesterase inhibitors.34 Although none of these have yet been tried in humans, they may have a role in reducing the injury to skeletal muscle following reperfusion in the future.

There was a mean delay of 22 hours before initial operative stabilisation in the ten patients who presented with severe elbow swelling. This was due to a combination of factors such as late presentation to the tertiary hospital and availability of operating time. We were unable to quantify the relative contribution of each of these factors in this retrospective review. The number of patients in this study is small, but in keeping with the rarity of compartment syndrome as a complication of paediatric supracondylar humeral fractures presenting without vascular compromise. This study suggests that excessive delay in treatment may play an important role in the evolution of a compartment syndrome, which is consistent with the current literature.4 Various treatments have been studied in small- and large-animal compartment syndrome models in an attempt to reduce the skeletal muscle injury during reperfusion, such as oral vitamin C,32 dichloroacetate33 and selective type III phosphodiesterase inhibitors.34 Although none of these have yet been tried in humans, they may have a role in reducing the injury to skeletal muscle following reperfusion in the future.

Compartment pressures were measured in only two of the patients in this series. Pressure monitoring may be used...
when a compartment syndrome is clinically suspected, with an absolute compartment pressure greater than 30 mmHg or within 20 mmHg to 30 mmHg of diastolic blood pressure in the affected limb being an indication for fasciotomy. Although elevated pressures alone are an insufficient indication for fasciotomy, they are helpful in the decision-making process.

There are limitations to this study inherent in any retrospective review. Data collection was limited by the accuracy of the documentation. We cannot comment on the true incidence of compartment syndrome, as we have no data regarding the total number of cases of supracondylar fracture managed by the treating hospitals during the study period, and most of the surgeons contacted did not have cases meeting our inclusion criteria.

In conclusion, this study demonstrates that isolated, low-energy paediatric supracondylar humerus fractures with an intact radial pulse may develop a compartment syndrome, and in our opinion, supracondylar fractures presenting with excessive swelling should be considered at increased risk of developing a compartment syndrome if treatment is delayed.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References