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Original article

Factors associated with a failed closed reduction for supracondylar fractures in children

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ABSTRACT

Purpose of the study: The aim of this retrospective study is to analyze the risk factors causing the failure of closed reduction of children supracondylar fracture.
Patients and methods: The children with supracondylar humerus fractures who were treated in our hospital from February 2008 to February 2013, were recorded as well as their age, sex, BMI, injured side, mechanism of injury, associated injuries, fracture type, delay from injury to surgery. Mean comparisons or Chi^2 test were used for univariate analysis of the above factors, and then multivariate logistic regression analysis was used to analyse the possible risk factors, in order to elicit the risk factors associated with a failed closed reduction for supracondylar fractures in children.
Results: Univariate analysis showed that BMI, fracture type, duration from injury to surgery, and mechanism of injury had statistically significant association with the failure of closed reduction for children supracondylar fracture (*P = 0.021, 0.044, 0.000 and 0.037 respectively). Multivariate logistic regression analysis demonstrated that fracture type (P = 0.027, OR = 1.177), time from injury to surgery (P = 0.022, OR = 2.003), and mechanism of injury (P = 0.044, OR = 4.182) were independent risk factors of a failed closed reduction for paediatric supracondylar fractures.
Discussions: Gartland type III supracondylar fractures, the peak period of soft tissue swelling and high-energy injury are significant risk factors to warrant open reduction. Treating surgeons should preoperatively carefully evaluate these risk factors and be prepared to treat these injuries accordingly.
Level of evidence: Level IV retrospective study.

1. Introduction

Pediatric supracondylar humerus fractures are the most common fractures around the pediatric elbow [1,2]. Because remodeling is limited, meticulous reduction and anatomic alignment are essential to restore normal elbow function and prevent future complications from malreduction and resultant abnormal joint kinematics. Closed reduction followed by stabilization with percutaneous Kirschner wires has been established as the standard treatment for unstable supracondylar fractures of the humerus in children, and a number of studies have shown satisfactory results with such treatment [1–5]. However, a totally displaced supracondylar humerus fracture is one of the most difficult fractures to manage because of marked soft tissues swelling and difficulty in achieving satisfactory reduction and maintaining reduction in the process of pinning. This means that a certain proportion of fractures cannot be reduced with the closed method, with the conversion rate to open reduction being between 3 and 15% [2,3,6]. Open reduction may have worse results than closed reduction as loss of motion, elbow stiffness, myositis ossificans, infection, scar formation and an increased risk of iatrogenic neurovascular injury are possible complications [6]. But few studies address some factors that may determine whether open reduction is performed when a closed reduction has failed.

The purpose of this retrospective study is to investigate the risk factors causing the failure of closed reduction of children supracondylar fractures. Some authors believed that the severity of the fracture and injury to surgery time might be associated with a higher rate of failed closed reduction [3,6]. Based on the views expressed above, we hypothesized that fracture type and time from injury to surgery were significant risk factors for the need for open reduction.

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2. Patients and methods

2.1. Study population and study design

After approval from Institutional Review Board of our hospital, we retrospectively reviewed the records of consecutive patients with operatively treated pediatric supracondylar humerus fractures who were admitted between February 2008 and February 2013 at our clinic. The inclusion criteria were: age 5.0–13.0 years, fresh closed fractures, unstable Gartland II and all Gartland III fractures, all operations performed by the same group of doctors, and Blount's technique failed or was contraindicated. The following patients were excluded: open fractures and old fractures, pathological fractures, combined with nerve or vascular injury, a history of ipsilateral elbow congenital malformations, associated with vital organs damage, and associated with fractures of other parts of the ipsilateral limb. In accordance with the inclusion criteria and exclusion criteria, a total of 104 patients with operatively treated supracondylar humerus fractures were identified.

2.2. Demographics of the study population

When Blount's technique failed and closed reduction of the fracture was satisfactory, percutaneous pinning was performed. When closed reduction was not satisfactory, open reduction was performed. Among 104 patients, open reduction was performed in 21 cases, including 13 males and eight females, seven cases on the left and 14 cases on the right, with a median age of 8.43 ± 2.30 years. The average body mass index (BMI) of the patients was $28.62 \pm 3.81\ kg/m^2$. It consisted of 3 cases of Gartland II fracture, 18 cases of Gartland III fracture. Causes of injuries were road traffic accidents in five patients, ground falls in nine and sports injuries in seven cases. We defined ground falls as low-energy injury and traffic accidents and sports injuries as high-energy injury. The time from injury to operation was < eight hours in five cases, eight hours to five days in 13 cases, five days to seven days in three cases. The remaining 83 cases were successfully reduced using the closed method, including 55 males and 28 females, 33 cases on the left and 50 cases on the right, with an average age of 8.90 ± 2.60 years. The BMI of the patients was $25.27 \pm 3.93\ kg/m^2$. It included 31 cases of Gartland II fracture, 52 cases of Gartland III fracture. Causes of injuries were road traffic accidents in 12 patients, ground falls in 56 and sports injuries in 15 cases. The time from injury to operation was < 8 hours in 44 cases, eight hours to five days in seven cases, five days to seven days in 32 cases.

2.3. Data collection

All demographic and outcome data were gathered by two authors and stored anonymously in a database. Demographic information recorded at the time of the original injury included age, sex, BMI, fracture type, mechanism of injury, and the time from injury to operation. Fracture was classified using Gartland fracture classification system. The main outcome variable was the need for open reduction. Indications for open reduction were a fracture irreducible by closed reduction or a fracture with unacceptable reduction. An unacceptable reduction was defined as excessive translational or rotational malalignment. Translational malalignment was defined on a lateral radiograph when less than 50% cortical contact existed between the proximal and distal fragments (Fig. 1). Rotational malalignment was defined on a lateral radiograph when a 2 to 3 mm difference existed in the width of the bone at the fracture site between the proximal and distal fragments (Fig. 2). Greater angular malalignment was accepted because this has a greater potential for correction through remodeling.

Fig. 1. Lateral radiograph showing translational malalignment.

Fig. 2. Lateral radiograph showing rotational malalignment.

2.4. Statistical analysis

Distributions of data were checked. Percentages were used for categorical data, and means or medians were used for continuous data. Student's t test was used for the comparison of continuous variables and the Chi^2 test for the comparison of categorical variables. The open reduction group was compared with closed reduction patients on collected variables. To determine whether factors were independently associated with risk of open reduction, a multivariate logistic model was fit predicting open reduction status. All variables were included as possible predictors and a final model was found using stepwise elimination. Final modeling results are reported with odds ratios (OR) and 95% confidence intervals (CIs). All analyses were performed using SPSS software, version 11.0 (SPSS, Inc., Chicago, IL, USA). The level of significance was set at $P < 0.05$.