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## Clinical study of emergency treatment and selective closed reduction for the treatment of supracondylar humerus fracture in children

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### ABSTRACT

**Objective:** To study the effect of emergency treatment, selective closed reduction combined with percutaneous Kirschner wire fixation on the treatment of Gartland type-II and type-III supracondylar humerus fracture.

**Methods:** Children who sustained the Gartland type-II and type-III supracondylar fractures of humerus treated with selective closed reduction combined with percutaneous Kirschner wire fixation in our hospital from May 2012 to August 2015 were analyzed retrospectively. They were divided into group A (emergency operation group) and group B (selective operation group) according to different operation timing. Perioperative situation, blood biochemical parameters, swelling degree and elbow joint function of affected limb were compared between two groups.

**Results:** Operation time for patients of group A was significantly shorter than that of group B [(17.19 ± 2.85) vs. (21.43 ± 3.91) min], and frequency of fluoroscopy during operation of group A was obviously less than that of group B [(6.03 ± 0.95) vs. (7.61 ± 0.92) times]. Swelling index of affected limb in group A at 3 days, 5 days and 7 days after injury was all significantly lower than that in group B [(1.20 ± 0.17) vs. (1.38 ± 0.14), (1.13 ± 0.13) vs. (1.30 ± 0.18), (1.02 ± 0.15) vs. (1.22 ± 0.15)]. Hospital for special surgery score at 1 week, 2 weeks, 3 and 4 weeks after removing Kirschner wire had no significant difference between group A and B (88.75 ± 10.18) vs. (89.14 ± 10.52), (94.22 ± 10.85) vs. (93.85 ± 11.08), (95.52 ± 11.27) vs. (95.92 ± 12.19), (95.43 ± 10.96) vs. (96.02 ± 11.38). Contents of serum alanine transaminase, aspartate aminotransferase, total protein, albumin and C-reactive protein in perioperative period had no obvious difference between patients in group A and B.

**Conclusions:** Emergency closed reduction combined with percutaneous Kirschner wire fixation for Gartland type-II and type-III supracondylar humerus fracture in children has less trauma, low swelling degree of affected limb in perioperative period, and good effect on the recovery of the elbow joint function after operation.

## 1. Introduction

Supracondylar humerus fracture is one of the most common types of fracture in children, of which the Gartland type-I closed

fracture, no obvious displacement with intact anterior and posterior periosteum, can be treated well by manual reduction and plaster external fixation. While the Gartland type-II and type-III closed fractures have a significant displacement leading to a very difficult and complicated clinical procedure<sup>[1,2]</sup>. At present, the common clinical therapies for Gartland type-II and type-III fractures include manual reduction, external plaster fixation, open reduction and internal fixation and closed reduction combined with internal Kirschner wire fixation, and so on. The recurrence rate of fracture displacement after operation was high due to the small plane contact areas of broken ends from Gartland type-II and type-III supracondylar humerus fracture, the swelling of soft tissue subsides after fractures reduction, and incoordination of children of hyperactivity in therapy of immobilization<sup>[3,4]</sup>.

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In recent years, clinical academics have basically reached a consensus on the operation method for Gartland type-II and type-III supracondylar humerus fracture. Closed reduction and percutaneous Kirschner wire fixation has been considered as the preferred treatment, which avoid a great trauma caused by open reduction and internal fixation and also the displacement of fracture ends caused by external plaster fixation<sup>[5,6]</sup>. However, the operation timing of closed reduction and percutaneous Kirschner wire fixation for Gartland type-II and type-III supracondylar humerus fracture in children has not yet reached an agreement. In the following study, we compared the effect between emergency treatment and selective closed reduction combined with percutaneous Kirschner wire fixation for Gartland type-II and type-III supracondylar humerus fracture.

## 2. Materials and methods

### 2.1. Subjects

Children who sustained the Gartland type-II and type-III supracondylar humerus fracture treated with selective closed reduction combined with percutaneous Kirschner wire fixation in our hospital from May 2012 to August 2015 were analyzed retrospectively, and the inclusion criteria were as follow: (1) their age was from 3 to 12 years; (2) their fracture time was not longer than 8 h; (3) they were suffering from unilateral supracondylar fractures of humerus and diagnosed as Gartland type-II or type-III fractures using imaging test after admission to hospital; (4) they had reached the operative indication and received treatment of closed reduction combined with percutaneous Kirschner wire fixation after admission to hospital; (5) their medical records were complete. Exclusion criteria were as follows: (1) children combined with brain, chest and abdomen injuries; (2) children combined with another parts of fractures; (3) children suffering from open fracture; (4) children with bad terminal blood circulation. A total of 103 cases were recruited and divided into group A (emergency operation group) and group B (selective operation group) according to the medical history review and different operation timing.

### 2.2. Operation methods

Children of both group A and B were treated by giving vein combined with brachial plexus anesthesia by doctors of the same group. Children from group A took operation after 8 h from injury, while children from group B took operation after 3–5 days from injury. The operation methods were as follows: patients were put down in supine position and the affected limbs were kept a little outstretched; elbow joint was half folded for traction after disinfecting the drapes; epitrochlea was touched with fingers after manual reduction to make sure that the bones were flat and complete without a sense of steps; two Kirschner wires were driven percutaneously into the opposite cortical bone started from lateral condyle until there was a sense of unimpeded. Posterior, anterior and lateral X-ray examination of distal humerus were carried out during operation to make sure that reduction of distal humerus and the placement of Kirschner wire were satisfactory, and then the third Kirschner wire was placed in; X-ray examination was used again to adjust the position of Kirschner wire. The elbow joint flexed to 90° and fixed externally with plaster after operation; the plaster was removed 3

weeks later and the Kirschner wires were removed 4–5 weeks later based on the fracture healing.

### 2.3. Evaluation of preoperative period situation

Operation time and X-ray examination times of two groups were recorded during operation. The limb swelling index was assessed after 1 day, 3 days, 5 days and 7 days from injury according to the following methods: the circumference of the most obvious swelling part of the affected limbs was measured, and the circumference of same part of opposite unaffected limbs was measured then. The circumference of affected/unaffected limbs was used as the limb swelling index. The samples of peripheral blood were collected and the blood serum was separated at 1 day before and after the operation respectively. Fully automatic biochemical analyzer was used to detect the alanine transaminase (ALT), aspartate aminotransferase (AST), total protein (TP), albumin (Alb) and C-reactive protein (CRP). Hospital for special surgery scoring system (HSS) was used to evaluate the elbow joint function of children in two groups after 1 week, 2 weeks, 3 weeks and 4 weeks from removing the Kirschner wire after operation.

### 2.4. Statistics methods

Software SPSS version 19.0 was used to analyze the data. Measurement data were expressed as mean  $\pm$  SD and analyzed using *t*-test. Enumeration data were described using frequency and analyzed using *Chi*-square. Difference was considered statistically significant when *P* is less than 0.05.

## 3. Results

### 3.1. General clinical data of children in two groups

There were 56 cases in emergency operation group (group A) which included 32 cases of boys and 24 cases of girls whose age was [(6.61  $\pm$  0.92) years]. And there were 35 cases of children diagnosed with Gartland type-III fracture and 21 cases diagnosed with Gartland type-II fracture. The timing from injury to admission to hospital was [(5.86  $\pm$  0.82) h] and the timing from injury to operation was [(4.94  $\pm$  0.77) h]. There were 47 cases in selective operation group (group B) which included 28 cases of boys and 19 cases of girls whose ages were [(6.48  $\pm$  0.83) years]. And there were 30 cases diagnosed with Gartland type-II fracture and 17 cases diagnosed with Gartland type-III fracture. The timing from injury to admission to hospital was [(6.02  $\pm$  0.79) h] and the timing from injury to operation was [(9.95  $\pm$  11.38) h]. Both two groups were of no significant difference in gender, age, fracture type and timing from injury to admission to hospital, but the timing from injury to operation of group A was obviously shorter than that of group B (*P* < 0.05) (Table 1).

### 3.2. Perioperative situation

The operation time from group A was significantly shorter than that of group B [(17.19  $\pm$  2.85) vs. (21.43  $\pm$  3.91) min], and frequency of X-ray examination during operation from group A was obviously less than that of group B [(6.03  $\pm$  0.95) vs. (7.61  $\pm$  0.92) times] (*P* < 0.05). There was no obvious difference of swelling limbs index between two groups after 1 day from

**Table 1**

General clinical data of two groups.

Items	Group A (n = 56)	Group B (n = 47)	P
Gender (Boy/Girl)	32/24	28/19	> 0.05
Gartland type-II/III fracture	35/21	30/17	> 0.05
Age (y)	6.61 ± 0.92	6.48 ± 0.83	> 0.05
Timing (from injury to admission) (h)	5.86 ± 0.82	6.02 ± 0.79	> 0.05
Timing (from injury to operation) (h)	4.94 ± 0.77	92.95 ± 11.38	< 0.05

injury [(1.38 ± 0.16) vs. (1.40 ± 0.18)]. The swelling limbs index from group A was significantly lower than that of group B after 3 days, 5 days and 7 days from injury, respectively [(1.20 ± 0.17) vs. (1.38 ± 0.14), (1.13 ± 0.13) vs. (1.30 ± 0.18), (1.02 ± 0.15) vs. (1.22 ± 0.15)] ( $P < 0.05$ ). The HSS after 1 week, 2 weeks, 3 weeks and 4 weeks from removing Kirschner wire was of no significant difference between two groups [(88.75 ± 10.18) vs. (89.14 ± 10.52), (94.22 ± 10.85) vs. (93.85 ± 11.08), (95.52 ± 11.27) vs. (95.92 ± 12.19), (95.43 ± 10.96) vs. (96.02 ± 11.38)], respectively.

### 3.3. Biochemical parameters during perioperative period

There was no significant difference of contents of serum ALT, AST, TP, Alb and CRP between two groups before operation. The contents of serum ALT, AST, TP, Alb and CRP after operation had no difference compared with those before operation. There was no obvious difference of contents of serum ALT, AST, TP, Alb and CRP between two groups after operation (Table 2).

**Table 2**

Biochemical parameters during perioperative period of two groups.

Items	Group A (n = 56)	Group B (n = 47)	P
ALT Before operation (IU/L)	22.59 ± 3.14	23.21 ± 4.66	> 0.05
ALT After operation (IU/L)	24.79 ± 4.42	24.14 ± 3.76	> 0.05
AST Before operation (IU/L)	18.86 ± 2.37	20.24 ± 3.92	> 0.05
AST After operation (IU/L)	21.34 ± 3.97	20.61 ± 3.68	> 0.05
TP Before operation (mg/L)	64.65 ± 7.97	65.10 ± 8.32	> 0.05
TP After operation (mg/L)	62.76 ± 8.41	63.20 ± 9.14	> 0.05
Alb Before operation (mg/L)	38.95 ± 6.82	39.24 ± 5.92	> 0.05
Alb After operation (mg/L)	37.69 ± 5.57	37.08 ± 6.14	> 0.05
CRP Before operation (mg/L)	7.94 ± 1.04	8.02 ± 0.92	> 0.05
CRP After operation (mg/L)	8.86 ± 1.08	8.57 ± 0.92	> 0.05

## 4. Discussion

The difficulties of clinical treatment for Gartland type-II and type-III supracondylar humerus fractures as follows: different from Gartland type-I supracondylar humerus fracture, Gartland type-II and type-III having obvious joint displacement, severely injured local soft tissues, small plane contact areas of broken ends, the poor compliance of children after fixation and the bad effect of immobilization. Therefore, only treated with the manual reduction and internal plaster fixation will easily cause the loss of reduction<sup>[7-9]</sup>. In recent years, the adoption of closed reduction combined with percutaneous Kirschner wire fixation

has reached an agreement to treat Gartland type-II and III fractures. This treatment uses Kirschner wire to fix, which successfully avoids the huge trauma caused by open reduction and internal fixation, and reduces the risk of complications such as synechia and hematoma after operation<sup>[10-12]</sup>. The surface of Kirschner wire is smooth, and it does not take up any space around the bone substance after fixation. The periosteum will be repaired by itself during fixation, which is helpful for the recovery of fracture and the restoration of joint function<sup>[13-15]</sup>. Several studies from international and domestic academics have shown that closed reduction combined with percutaneous Kirschner wire fixation treated for Gartland type-II and type-III supracondylar humerus fracture in children has achieved good results<sup>[16-18]</sup>.

Nevertheless, the timing of closed reduction combined with percutaneous Kirschner wire fixation for Gartland type-II and type-III supracondylar humerus fractures in children is still in dispute. Studies have reported that there is no obvious difference of postoperative complications following the treatment of Gartland type-II and type-III supracondylar humerus fractures between emergency operation and postponed operation<sup>[19,20]</sup>. In the study by Larson *et al.*, it was believed that reduction and percutaneous fixation after 12 h from injury have a more ideal curative effect and less postoperative complications<sup>[21]</sup>. While in the study of Mayne *et al.*, it proved that preliminary emergency reduction and fixation combined with postponed percutaneous fixation achieved the same definite curative effect<sup>[22]</sup>. It was found in our study that operation time of group A was shorter than that of group B, and frequency of X-ray examinations was less than that of group B as well comparing the situation during operation between emergency treatment and selective closed reduction combined with percutaneous Kirschner wire fixation for Gartland type-II and type-III supracondylar humerus fractures. In our study, we believed that the key factor of operation time and frequency of X-ray for closed reduction combined with Kirschner wire fixation depends on how difficult the reduction is. The limbs of group A did not swell as serious as it could be within 8 h of fracture, and the elasticity of soft tissues around broken ends was better, so it would be easier to touch the bone substance around broken ends and improve the success rate of manual reduction at this moment. While in group B, there appeared some edema in soft tissues when the subjects took operation after 3-5 days from injury, which effected the touch of bone substance during manual reduction and enhanced the difficulty of reduction, and as a consequence it extended the operation time and increased the frequency of fluoroscopy.

To further verify the accuracy of the studies on the limbs swelling degree during emergency operation and selective operation, we compared the swelling degree of affected limbs of two groups. The results were as follows: there was no difference of limbs swelling degree from two groups after 1 day from injury; the limbs swelling degree from group A was lower than that of group B after 3 days, 5 days and 7 days from injury. As it can be seen, there was significant improvement for the swelling of affected limbs after emergency operation, while the degree of swelling got worse gradually before selective operation, which also affected the operation of reduction. Though the degree of swelling got worse before selective operation, the blood circulation and the swelling of limbs were improved with the fracture reduction and Kirschner wire fixation, and it had no effect on the recovery of supracondylar humerus fracture and elbow joint

function with plaster fixation and exercise of body function. It was known from HSS of elbow joint function after emergency operation and selective operation that there was no significant difference of HSS between two groups after 1, 2, 3 and 4 weeks from removing Kirschner wire, and the recovery of elbow joint function after emergency operation and selective operation was much the same. Otherwise, there was no significant difference and obvious changes of ALT, AST, TP, Alb and CRP blood biochemical parameters in preoperative period from two groups.

In conclusion, emergency treatment with closed reduction and percutaneous Kirschner wire fixation for Gartland type-II and type-III supracondylar humerus fracture in children is of less trauma, low swelling degree of affected limbs during perioperative period and good recovery effect of the elbow joint function.

### Conflict of interest statement

The authors report no conflict of interest.

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