Original Clinical Article

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Postponing surgery of paediatric supracondylar humerus fractures to office hours increases consultant attendance in operations and saves operative room time

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Abstract

Purpose To assess if postponing surgery of paediatric supracondylar humerus fractures (SCHF) without compromised blood circulation to office hours can improve the quality of reduction and pin fixation and decrease complications.

Methods In 2004, night-time (0am to 7am) surgery was allowed only for children with compromised blood circulation. Number of open reductions, surgeons experience, operation time, quality of reduction (Baumann angle, anterior humeral line crossing point with capitellum) and pin fixation as well as the number of complications were compared in 100 children before (A) and 100 after (B) the new protocol. Surgery was commenced during office hours (8am to 3pm) in 27% (A) *versus* 55% (B) and delay to surgery from admission exceeded six hours in 25% (A) *versus* 52% (B) of the children.

Results Open reduction was performed in eight (A) *versus* 11 (B) children. In group A, 40% were operated on by a registrar alone compared with 14% in group B. Mean operation room time decreased by 11 minutes in group B. Radiographic alignment was satisfactory at fracture union in 68% (A) *versus* 68% (B) and radiologically stable pin fixation in 42% (A) *versus* 55% (B) of children (p = 0.08). The was no statistical difference in admission time, re-reductions, infections, permanent iatrogenic nerve injuries or corrective osteotomies between the patient groups.

Conclusions No statistical difference in quality of reduction or pin fixation or in number of complications was observed. Postponing operative treatment of SCHF without vascular compromise increased consultant attendance in operations and decreased operative room time.

Level of Evidence III - retrospective comparative study

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Introduction

The optimum time window for surgical treatment of displaced supracondylar humerus fractures (SCHF) in children has been a matter of much debate. Emergent pin fixation has been justified to stop swelling which could at least theoretically reduce the number of open reductions and decrease complications, such as compartment syndrome, nerve injuries and infections.[1] However, significant differences in complication rates have not been found between children with closed SCHF with satisfactory peripheral circulation treated emergently and semi-electively.[1,2] It has thus been proposed that pin fixation of a displaced SCHF in a child with normal distal pulses can be safely performed within 24 hours from the injury.[1-3]

The standard of reduction has been traditionally assessed in radiographs. Frontal alignment can be evaluated by measuring the Baumann angle (BA), the angle between the long axis of the humeral shaft and the growth plate of the lateral humeral condyle with reported normal values between 64° and 81°.[4-7] The most common way to register sagittal alignment is to record if the anterior humeral line (AHL) passes through the anterior or middle third of the ossification center of capitellum.[8-9] Rotatory alignment can be assessed but not measured in plain radiographs. Quality of SCHF treatment correlates with the experience of the institution: unsatisfactory standard of reduction and pin fixation are the most common reasons for malunion and for iatrogenic nerve injuries in

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displaced SCHF.[10] Operative treatment of paediatric SCHF is thus ideally performed by a consultant surgeon or by a registrar with consultant back-up in teaching hospitals.

It has been shown, that by cutting down evening and night-time operations, symptoms of fatigue and exhaustion of the personnel and the cost of treatment can be reduced when the quality of care (decrease in reoperations in fracture patients) is simultaneously improved.[11]

The purpose of this study is to assess if quality of operative treatment in paediatric SCHF can be improved by better standard of reduction and pin fixation assessed in radiographs and decrease in complications when night-time (0am to 7am) surgery is performed only in children with compromised distal blood circulation.

Materials and methods

A total of 200 consecutive children that had pin fixation of SCHF in Helsinki Children's Hospital were included in this study between June 2002 and March 2007. The first 100 (group A) children were treated before November 2004, after which night time (0am to 7am) surgery of SCHF was restricted to children with compromised distal blood circulation only (group B, n = 100).

The mean age of the children at surgery was 7.1 years (1.8 to 14.1). In all, 107 (54%) of all children were boys and 108 (54%) left-sided. The most common trauma mechanisms were falling from height (53%), sporting activities (31%) and falling on a level (15%). Three children had sustained a high-energy trauma, whereas the aetiology of the fracture was unknown in two. Nearly all (99%) fractures were extension type injuries (Gartland III 83.5%, Gartland II 15.5%). Eight children had an open fracture.

There was no difference in gender (p = 0.77), age (number of children younger than ten years, p = 0.45), trauma mechanism (p = 0.36 to 1.00) or number of open fractures (five group A, three group B; p = 0.72) between the two patient groups. Slightly more children had sustained a grade II fracture in group A than in group B (p = 0.12) (Table 1).

Table 1 Findings between group A (patients before postponing operative treatment of supracondylar humerus fractures to office hours, n = 100) and group B (after postponing operative treatment, n = 100) patients

	Group A	Details	Group B	Details	p-values
Classification					
Gartland II	20		11		0.12
Gartland III	79		88		0.13
Flexion	1		1		1.00
Open reduction					
	8		11		0.63
Number of pin(s) crossing both fracture fragments					
≥ 2 stable	39		52		0.08
≥ 2 unstable	5		6		
1	42		27		
0	7		9		1.00
Unknown	7		6		
Baumann angle					
Mean	79		77		
Normal	55		70		0.07
> 10˚ abnormality	5		6		1.00
Unknown	13		10		
Anterior humeral line crossing with the capitellum					
No	11		12		1.00
Yes	82		82		
Unknown	7		6		
Rotation					
Yes	15		18		0.70
No	77		76		
Unknown	8		6		
Hospital days					
Mean	1,2	*Range 0 to 7*	1,3	*Range 0 to 5*	
Fracture complications					
Nerve injury	14		21		0.26
Median	8	*5 preoperatively*	11	*9 preoperatively*	
Ulnar	6	*2 preoperatively*	4	*2 preoperatively*	
Radial	3		5	*3 preoperatively*	
Vascular injury	1	*Brachial artery exploration*	1	*Brachial artery repair*	1.00
Complication of treatment					
Nerve injury	1	*Partial median nerve repair*	1	*Ulnar nerve exploration*	1.00
Unsatisfactory reduction					
Re-reduction	1		0		1.00
Corrective osteotomy	1	*Varus deformity*	1	*Varus deformity*	1.00
Infection	5	*1 deep infection*	3		0.72

p-values were calculated using Fisher's exact test.

The number of different consultants (board qualified orthopaedic surgeon, range of number of operations seven to 30) and registrars (in final three years of a six-year training to either orthopaedic of paediatric surgeon, range of number of operations one to 21) performing surgery was eight and 26 in group A and nine and 21 in group B.

There was one child in group A that had her brachial artery explored and another child in group B that had a brachial artery reconstruction with synthetic graft emergently. No Volkmann's contracture was diagnosed. The rate of nerve palsy was similar in both patient groups (p = 0.26) (Table 1).

Surgery was commenced during office hours (8am to 3pm) in 27% (group A) versus 55% (group B) of the children (p < 0.0001). Length of time to surgery from admission exceeded six hours in 25% (group A) versus 52% (group B) of the children (p < 0.0001). Number of operations performed during weekends was the same in both treatment groups. Night-time procedures (0am to 7am) decreased from 12% (group A) to 2% (group B) after the new regulation (p = 0.01).

All available radiographs were analyzed by a paediatric radiologist (RK) and an orthopedic registrar (NT) (87 patients in group A (seven children lacked postoperative radiographs and in six the radiographs were unusable) and 90 patients in group B (seven children lacked postoperative radiographs and in three the radiographs were unusable)). Quality of the osteosynthesis was evaluated by analyzing the number of pins fixing both fracture fragments and their configuration (pins should not cross at fracture level). Radiographic alignment was considered satisfactory at fracture union if BA was within ±10° of reported normal range and the AHL crossed the capitellum with no malrotation at fracture union. Data was retrospectively collected from patient records. Statistical analysis was performed using Fisher's exact and Wilcoxon tests. A p-value ≤ 0.05 was considered statistically significant. Power analysis was not done because of a retrospective study protocol.

Results

Open reduction was performed in eight (group A) *versus* 11 (group B) (p = 0.63) children. The ratio of operation performed alone by a registrar dropped from 39% to 14% after intervention to treatment protocol was done in November 2004. On the other hand, the rate of operations performed by a consultant with a registrar increased from 51% to 73% and the number of operations performed by a consultant as the main surgeon from 27% to 43% (p = 0.02). Of the fractures operated by a registrar alone and with a consultant assistance, 12/30 and 8/80 were Gartland grade II (p = 0.008).

Mean operative room time (including reduction, pin fixation and casting) decreased by 11 minutes from 54 minutes (15 to 147) in group A to 44 minutes (14 to 170) in group B (two children with vascular operations that lasted 228 and 175 minutes were excluded from this calculation). The sum of operation times was 16.5 hours longer in group A than in group B (93 hours 36 minutes versus 77 hours and eight minutes). The experience of the main surgeon had no impact on the mean operative room time (registrars mean operation time 0:50 (0:15 to 2:50) versus consultant mean operation time 0:46 (0:14 to 2:23) (p = 0.24)). The number of operations lasting less than 60 minutes increased from 67 to 84 after the new regulation (p = 0.008). The number of operations lasting over 120 minutes decreased from nine to three after the new regulation (p = 0.14).

Re-reduction was necessary because of unsatisfactory fracture alignment in one Gartland grade II child operated by a registrar at 8pm in group A (p = 1.00) (Fig. 1). One deep infection in group A was treated with revision surgery, this child with closed Gartland grade III fracture was operated by a registrar at 6pm. Superficial pin tract infections that healed uneventfully with per oral antibiotics were recorded in seven additional children (four in group A and three in group B) (Table 1).

The rate of children with radiologically stable pin fixation (two or more pins not crossing at fracture line puncturing both fracture fragments) increased from 42% (group A) to 55% (group B) (p = 0.08). Partial loss of reduction was observed in five children (four in group A, one in group B) with no further treatment. At fracture union, radiographic alignment was satisfactory in 68% of children in both groups (59/87 and 61/90). No difference between the groups regarding the BA within ±10 of reported normal range (82% (group A) versus 84% (group B); p = 0.85), ratio of children with AHL crossing the capitellum (82% in both groups) or the ratio of children that had no rotation evident on radiographs (77% (group A) versus 76% (group B); p = 0.70) (Table 1).

One verified iatrogenic nerve injury was diagnosed in both groups (Table 1). In group A, one child's ulnar nerve was found pierced and partially lacerated by a Kirschner-wire. In group B, one child's median nerve was found partially entrapped in the fracture gap, released and repaired with partial recovery. Both these children were operated during office hours by or with a consultant orthopaedic surgeon attending.

One varus deformity was corrected by osteotomy in both groups (Table 1). Group A patient's fracture was operated by a registrar alone and group B's patient by a registrar and consultant together.

Discussion

We have assessed the effect of postponing surgery of children with SCHF with late evening or night admission with

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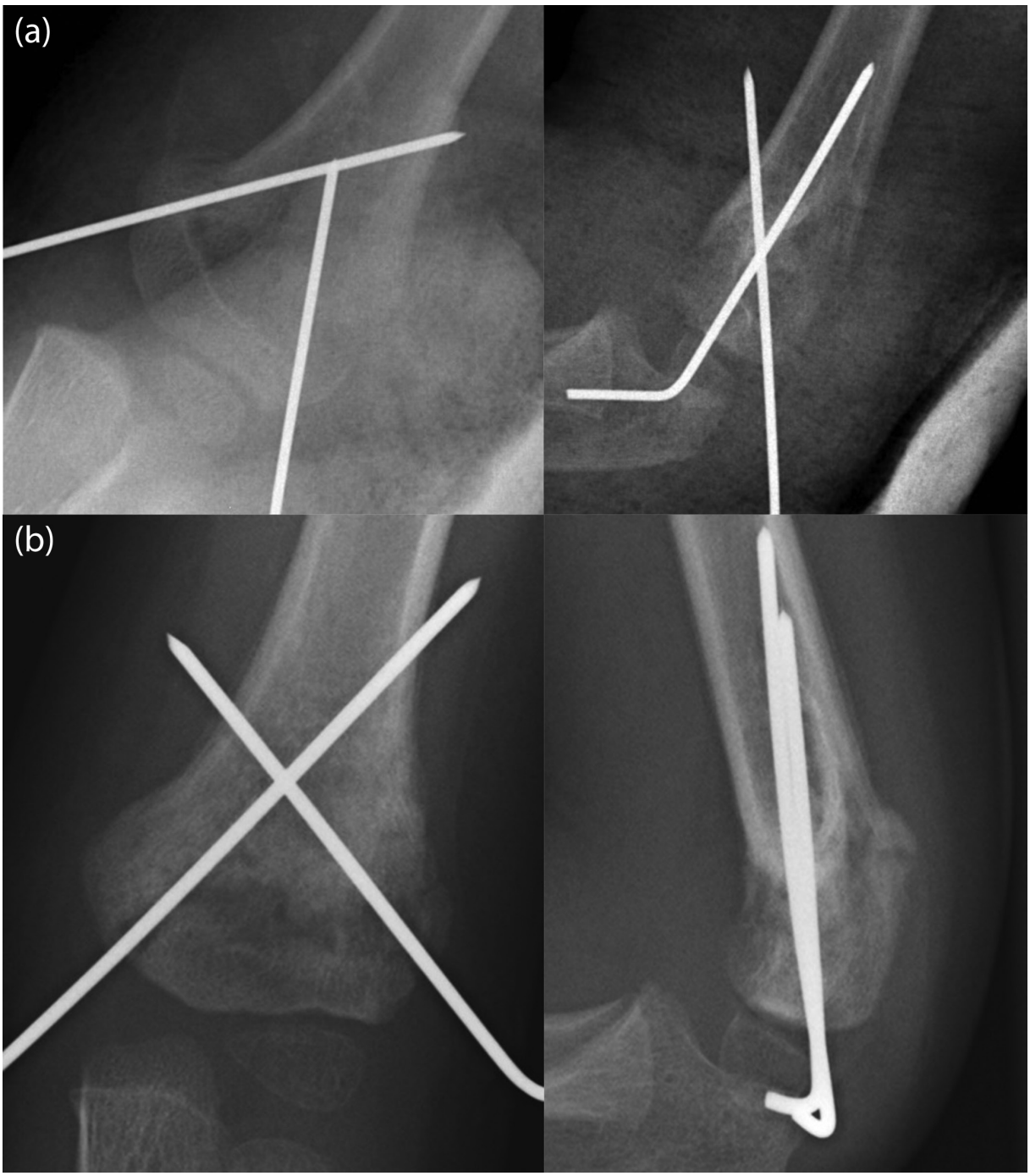

Fig. 1 Postoperative radiographs after first reduction and pin fixation of Gartland grade II fracture (**a**). Re-reduction was performed at the first postoperative day. Control radiographs at fracture union (three and five weeks after the reoperation) (**b**).

normal blood circulation to office hours. We examined the ratio of operations performed by registrars alone, operation time, quality of reduction and pin fixation assessed from radiographs, treatment complications and costs of treatment. This is a retrospective intervention study and comparisons between the two treatment groups should therefore be interpreted with caution.

Displaced SCHF is the most common operatively treated fracture type in children. Pin fixation of a displaced SCHF is, however, technically difficult, especially for unexperienced surgeons. Liu et al[12] has reported that the rate of non-ideal reductions of SCHF performed by registrars is higher without a consultant attending present, with improved outcome only after the first 15 procedures. The number of

operations performed by a registrar alone dropped to 14%, and the rate of a consultant attending surgery increased to 80% after SCHF treatment became time regulated in November 2004 in Helsinki Children's Hospital. Consultant assistance is thus more available during office hours than during the night despite a 24/7 consultant back-up always being arranged for registrars in our hospital.

According to a meta-analysis of the literature by Loizou et al,[13] delay in treatment of displaced SCHF can increase swelling and, therefore, possibly also the rate of open reductions, although no change in the operation times has been reported.[13-16] The results of this study support earlier findings[1-2,14,17] that the rate of open reductions does not increase significantly by delaying surgery to office hours. The mean duration of operation time decreased by 11 minutes after the new regulation was launched, which was probably due to the fact that more operations were performed or assisted by an experienced surgeon than before, even though this may not be the only explanation, since operative room time between registrars and consultants was not significantly different. However, comparison between these two surgeon groups is impossible, since children operated on by registrars alone were more likely to have Gartland grade II fractures. A substantial amount of operative theatre time (16.5 hours) was saved after the new regulation. Furthermore, there was a shift to less expensive operative room time during daytime (on call operation room costs are 30% more expensive in our hospital). There was no increase in the length of hospital admission after the new regulation. Thus, treatment of displaced paediatric SCHF became less expensive after November 2004 in our hospital.

The rate of treatment-related complications, such as unsatisfactory pin fixation, nerve injuries, compartment syndrome or infections, has not been reported to increase after delaying operative treatment of displaced SCHF from eight to 12 hours.[1-2,14-15,17-18] Our findings are concurrent with these earlier studies with the same rate of iatrogenic nerve injuries (1%) in both study groups; vascular catastrophes leading to Volkmann's contracture were not encountered. Quality of reduction assessed from radiographs remained the same. After the new regulation, acute re-operation rate decreased from three to 0, quality of pin fixation improved (radiologically stable pin fixation rate increased from 42% to 55%) and partial loss of reduction decreased from 4% to 1%, even if without statistical significance. In our opinion, the quality of reduction and pin fixation is not satisfactory and improvement has been accomplished with better operative guidance at our hospital.[19] Although postponing operative treatment of displaced SCHF to office hours has several positive consequences, a longer wait in hospital before surgery after admission can on the other hand cause anxiety in children and their parents. Therefore, repeat clinical assessment of neurovascular findings and adequate preoperative pain management is a must if operative treatment of displaced fractures is postponed to office hours.

Summary

Concentrating operative treatment of displaced paediatric SCHF to office hours increases attendance of consultant in operations. Evidenced decrease in operation room time without change in complication rate or admission in days decreased expenses of treatment in our study. No statistical difference in quality of reduction or pin fixation was observed.

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COMPLIANCE WITH ETHICAL STANDARDS

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ETHICAL STATEMENT

The study protocol was approved by the Ethics Committees of Gynaecology and Paediatrics of Helsinki University Hospital (346/13/03/03/2012).

ICMJE CONFLICT OF INTEREST STATEMENT

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