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Original Article

Predicting cubitus varus in supracondylar fractures of the humerus by Baumann's angles in post reduction X-rays

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Abstract
Objectives: The present study presents the technique to predict cubitus varus by post reduction Affected Side and Normal Side Baumann's angle difference (ASBA and NSBA) respectively. It intends to correlate the Baumann's angle to the final carrying angle of the injured elbow and presents the relevant mathematical clinical rule along with its prediction test characteristics.
Material and Methods: Total 57 patients of 6.5±1.67yrs, 22 were males and 8 females with 19/30 having left side injury. Isolated closed supracondylar fractures of humerus up to 5 days duration included and previous trauma, pathological fracture, other injury, elbow disease were excluded .30/57 completed >1 year follow-up.
Results: The Mean NSBA was 74.4±4.14º. The mean normal side carrying angles (NSCA) were 9.56 ± 2.2º. The NSCA IQR (Inter Quartile Range) was 8.8-10º. The ASBA was 79.9±9.1º and affected side carrying angles (ASCA) was 0.20±8.7º. The ASCA was best predicted by the difference between ASBA-NSBA (ASCA=3.87-0.65(ASBA-NSBA; F=15.91). At a cut off of 8.8º (the lower limit of IQR for NSCA), a value >0º for ASBA- NSBA was 80% predictive of cubitus varus. With pre test probability of varus at 70%, sensitivity was 0.94 and specificity 0.42.
Discussion: A prediction rule to predict the final carrying angle from ASBA NSBA difference is presented with a positive predictive value 0.80, specificity of 0.42, and sensitivity of 0.94 at a pre test probability of 0.70.When the diagnosis of cubitus varus is ASCA<8.8º (Lower limit of the IQR for NSCA).
Conclusion: If affected side Baumann's Angle – Normal Side Baumann's Angle is equal to or greater than 0 then there was 80% probability of having cubitus varus.

Key words: Supracondylar fractures of humerus, Baumann's angle, Complications, Carrying angle, Cubitus Varus.

Supracondylar humerus is the second most common fractures in children seen most frequently before the age of seven years. 30% develop cubitus varus.[6, 7] This does not correct with remodelling and is cosmetically unacceptable especially in girls in the developing country settings. A precise rule to define unacceptable reduction from the cubitus varus perspective in the immediate post reduction film can help precisely target re reduction to the high-risk group thus increasing the efficiency of preventing this complication. We therefore present a simple rule to define radio logically cases where reduction should be redone. The distal humerus in children has a diamond shaped olecranon fossa bounded on the lateral and medial side by very thin plate of the cortical bone that forms two thin pillars. Disruption of the pillars is the main cause of the rotation and tilt that leads to the cubitus varus deformity. The pathology can be objectively measured by the Baumann's angle. The Baumann's angle is the shaft - physis angle of the distal humerus and the gives a measure of the residual post reduction displacement which should predict cubitus varus. This has been found to be consistently relevant in predicting the varus deformity following the supracondylar fracture. The same relation can be measured in three ways[1]. First, as the angle between the long axis of the humerus and the line parallel to the physis of the lateral condyle of the distal humerus. Second, the angle between the perpendicular to the long axis of the humerus and line through the physis of the lateral condyle. And third the angle between the line through the physis of the lateral condyle and line connecting the point on the edge of the trochlea to a point at the lateral limit of the physis of the lateral condyle.

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The 1st technique is the most frequently used and so we had used it also.[1, 4] The carrying angle is not considered as a secondary sex character[5]. Carrying angle being an anthropometrics measurement can show variations in its measurement. A linear relation between the Baumann's angle and the carrying angle could have made the first predict the other. Even if the relation is non linear increase in the Baumann's angle should predict the probability of high risk for cubitus varus and Identify cases needing re reduction.

There was no significant difference between the Baumann angle after reduction and that measured at follow-up; and it is suggested that this angle after reduction can be reliably used to predict accurately the final carrying angle.[8, 3 ,4]. This angle measured after reduction may be used to predict the final carrying angle so that cubitus varus deformity can be effectively prevented. The present study presents the technique of doing exactly this. It intends to correlate the Baumann's angle to the final carrying angle of the injured elbow and presents the relevant mathematical clinical rule along with its prediction test characteristics.

Methods and materials

57 children between the age of 3-8 years of both sex who sustained isolated closed supracondylar fractures of the distal end of humerus between May 2001 to May 2002 and reported to the orthopaedic emergency of B P Koirala Institute of Health Sciences, Dharan, Nepal, a tertiary care centre in east Nepal, within 5 days of sustaining injury, form the study population. 30/57 completed the stipulated 1-year of follow up. Before reduction two standard antero-posterior and lateral X-rays were taken on the injured and the normal elbow and the fracture configuration assessed according to Gartland's classification. Closed reduction under general anaesthesia was done and POP cast immobilization done irrespective of Gartland's grading. Post reduction X-ray of affected elbow (antero-posterior shoot through view and lateral view) were taken and adequacy of reduction were assessed by Bauman's angle of the affected side equalling or greater than the Bauman's angle of the normal side. The patient was observed for a period of 24 hours and was called for review after 7 days to see the x-ray for adequacy of reduction. Another set of check x-rays was taken when the elbow attained full extension. Antero-posterior views of normal elbow were also taken for sake of comparison and Baumann's angles were measured. 30 out of 57 cases completed the 1-year follow-up and carrying angle was measured by an observer blind to the study hypothesis and the previous readings of Baumann's angle in the patient. The relation between the Baumann's and carrying angle is presented using analytic techniques to measure both the magnitude and probabilities in the association.

Results

30/57, completed >1 year follow-up. However, this loss to follow up has had no affect on the internal validity of the study and is unlikely to affect the external validity, as it is probably purely random. The age of the study group was 6.5±1.67 years, with male: female ratio of 2.7:1 (22 males and 8 females). Right: left ratio was 9:13 in males and 2: 6 in females. Carrying angle among males ranged from 30º varus to 100º valgus and 8º to 12º valgus on the unaffected side. Among females the range of carrying angle on the affected side was 70 varus to140º valgus and 60º valgus to 150º valgus on the unaffected side. The Baumann's angle in males on affected and unaffected side ranged from 60º to 94º and 64ºto 82ºrespectively. For the girls, it was 60º-88ºon affected and 60º-78ºon the unaffected side. The summary statistics for the frequency distribution of the angles were as follows. The mean Normal Side Baumann's Angle (NSBA) was 74.4±4.14º. The mean Normal Side Carrying Angle (NSCA) was 9.56 ± 2.2º. The NSCA IQR was 8.8-10º. The Affected Side Baumann's Angle (ASBA) was 79.9±9.1º and Affected Side Carrying Angle (ASCA) was 0.20±8.7º. The ASCA was best predicted by the difference between ASBA-NSBA. The model was ASCA=3.87-0.66(ASBA-NSBA); F=15.91; r2 = 0.28. At a cut off of 8.8º (the lower limit of IQR for NSCA) a value >0º for ASBA-NSBA was 80% predictive of cubitus varus. With pre test probability of varus at 70%, sensitivity was 0.94 and specificity 0.42.(Table 1) We present another model with less power (F-11.138) to predict the affected side carrying angle where X-ray of the normal side is not available (NSBA not available) here model in (Table 2) may be used.

Table 1: Linear Regression Analysis- Affected side carrying angle at >1 years =Affected side Baumann's angle – Normal side Baumann's angle Correlation Coefficient r^2=0.36

Source	Df	Sum of square	Mean of square	F-Statistics
Regression	1	796.924	796.924	15.917
Residual	28	1401.876	50.067	
Total	29	2198.800		
Variable	Coefficient	Standard Error	F-test	P-Value
Intercept	3.868	1.586	5.9511	0.02155
ASBA-NSBA	-0.659	15.9172	0.000455	

Table 2: For cases where the normal Baumann's angle is not available we present the following model to predict the affected side Carrying

Source	Df	Sum of square	Mean of square	F-Statistics
Regression	1	625.746	625.746	11.138
Residual	28	1573.054	56.180	
Total	29	2198.800		
Variable	Coefficient	Standard Error	F-test	P-Value
Intercept	40.889	12.269	11.1080	0.02503
ASBA	-0.509	0.152	11.1381	0.002475

Table 3: Two by two table to validate model 1 against the truth of cubitus varus defined as ASCA < 8.8 º

ASBA-NSBA	CUBITUS VARUS +nt	CUBITUS VARUS -nt	ROW TOTAL
0 or more than 0	16	4	20
Less than 0	1	3	04
Column total	17	7	24

Pre test probability =17/24=0.70
Sensitivity =16/17=0.94
Specificity=03/07=0.42
Negative predictive value=01/04=0.25
Positive likelihood ratio=01.64
Negative likelihood ratio=00.13
Positive predictive value=16/20=0.80

Discussion

If affected side Baumann's Angle – Normal Side Baumann's Angle is equal to or greater than 0 then there was 80% probability of having cubitus varus. An affected side-carrying angle of less than 8.8º. Cubitus varus is defined as carrying angle less than 8.8º because 8.8 is the lower limit of the IQR for carrying angle of the normal side. If we recommend re manipulation in test positives then we would not be wrong in even 1 out of 80 cases. However a test negative; ASBA being less than NSBA the probability of having cubitus varus was 40%. The pre test probability was 14/24 = 0.56. Likelihood Ratio for test positives is 7.8. Table 3. If only ASBA is available then model in Table 2 can be used to predict ASCA.

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