Secondary deformities of the shoulder in infants with an obstetrical brachial plexus lesions considered for neurosurgical treatment

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Object. The authors performed a prospective study in which magnetic resonance (MR) imaging was conducted in 26 consecutive infants (mean age 5.6 months, range 2.7–14.5 months) in whom recovery from an obstetric lesion of the brachial plexus had been inadequate in the first 3 months of life. The purpose was to identify early secondary deformations of the shoulder in obstetrical brachial plexus lesions (OBPLs).

Methods. Features of the shoulders were analyzed according to a standardized MR imaging protocol in patients with OBPLs. Measurements were made of the appearance of the glenoid, glenoid version, and the position of the humeral head.

The appearance of the glenoid on the affected side was normal in only 11 shoulders. In the remainder it was convex in eight and biconcave in seven cases. The degree of humeral head subluxation was significantly greater (p = 0.001) in affected shoulders than in normal shoulders (152 and 170°, respectively). The presence of abnormal glenoid retroversion and humeral head subluxation increased with age: there was a statistical difference (p = 0.001) between infants younger than 5 months of age and those who were older.

Conclusions. Magnetic resonance imaging demonstrates shoulder-related anatomical and nerve root lesion, allowing evaluation of neural, osseous, and cartilaginous structures in younger children.

KEY WORDS • obstetrical brachial plexus lesion • shoulder • deformity • subluxation • glenoid deformation

In most children with an OBPL, improvement of the neurological deficits can be expected within the 1st year of life. At present neurosurgical treatment is considered in infants with (sub)total lesions and those without biceps muscle function at 3 months of age. In these infants neuroimaging is part of the preoperative evaluation and is usually performed at 4 months of age. This examination focuses on diagnosing the type of lesions—that is, distinguishing neurotmesis from avulsion because regenerating axons cannot be expected in preganglionic spinal nerve root avulsions.

For the diagnosis of brachial plexus lesions in infants, MR imaging has surpassed computerized tomography myelography as the modality of choice. In applying different techniques in a noninvasive way, high-power MR images reveal plexus structures with great detail.

Although clinical symptoms are primarily caused by the brachial plexus lesion in infants with an OBPL, secondary deformities of the upper extremity may develop and influence the symptoms, predominantly around the shoulder.'
conducted to analyze the developing shoulder deformities. Their shortcoming is that they focus on the osseous structures. In this respect MR imaging better visualizes the predominantly cartilaginous shoulder in young children.

To assess the prevalence of secondary deformities of the shoulder in infants with OBPLs considered for neurosurgical reconstruction, we performed a prospective MR imaging-based study.

**CLINICAL MATERIAL AND METHODS**

**Patient Population**

This prospective study was based on a group of infants with OBPLs who were being considered for reconstructive procedures because of inadequate neurological recovery in the first 3 months of life. Twenty-six consecutive children with a unilateral OBPL (16 boys and 10 girls; mean age 5.6 months [range 2.7–14.5 months]; 11 left- and 15 right-sided lesions) were evaluated between July 1998 and September 2000. In all cases the cervical spine and shoulders bilaterally were examined using MR imaging. The severity of the neurological deficit was classified according to the system of Narakas11 (Table 1).

**Magnetic Resonance Imaging Protocol**

For the MR imaging investigation (Siemens Magnetom 1.5-tesla Vision; Siemens, Erlangen, Germany), the children received an intramuscular cocktail of pethidine, droperidol, and chlorpromazine. They underwent electrocardiography, oxygen saturation, and video monitoring. To visualize both shoulders a three-dimensional fast imaging with steady-state precession pulse-acquisition sequence imager (TR 25 msec, TE 10 msec, flip angle 40°) with 1.5-mm partitions was used. Measurements of both shoulders were performed in the axial plane at the midglenoid level.

Three established measurement methods were used in this analysis. In the first, the glenoid form was classified qualitatively as concave-flat, convex, or biconcave according to the system proposed by Birch, et al.,1 (Fig. 1). In the second method, the glenoid version angle was measured according to that described by Friedman, et al.,4—that is, the angle between the line connecting the base of the anterior and posterior labrum and the line connecting the middle of the glenoid and the medial margin of the scapula (Fig. 2). By definition 90° was subtracted from the aforementioned angle to determine the glenoid version angle. A negative value indicated a retroverted glenoid. Finally, in the third method, the subluxation of the humeral head was measured using a modification of the method described by Papilion and Shall;12 that is, the angle between the line medial margin of scapula/midpoint glenoid and the line midpoint glenoid/center of humeral head.

**Statistical Analysis**

All measurements were made on images in digital format by using postprocessing software (Radworks 4.0; Applicare Medical Imaging BV, Zeist, The Netherlands). Statistical significance of the differences between the pathological and normal side was tested using parametric tests for quantitative data and the Fisher exact test for nominal data.

**RESULTS**

There were no complications related to the sedation. All MR imaging studies were of adequate quality. Detailed patient-related data are presented in Table 2.

The glenoid form on the affected side was qualitatively normal in 11 shoulders. Pathological glenoids were convex in eight cases and biconcave in seven (Fig. 3). In addition the extent of humeral head subluxation was significantly greater (p = 0.001) in the shoulders on the affected side (152° compared with 170°, respectively) and the gle-
Shoulder deformities in OBPL

Fig. 2. Diagrams. A: The method of measuring the glenoid version angle according to Friedman et al. The angle in the posterior quadrant is measured, and 90° is subtracted from this angle to determine glenoid version. B: The method of measuring the posterior subluxation of the humeral head according to Papilion and Shall.


Glenoid version was different from the contralateral side (−11.4° and −5.4°, p = 0.004). There was no relation between shoulder deformities and Narakas grouping. Post-traumatic abnormalities were not seen.

Glenoid retroversion and humeral head subluxation increased as the patient aged. The influence of age became apparent when comparing younger (< 5 months) and older infants (≥ 5 months) within the study group. In infants younger than 5 months, the glenoid version angle and extent of humeral head subluxation of affected and normal shoulders were not significantly different (Table 3). In infants of 5 months of age and more, however, the extent of glenoid version and humeral head subluxation were significantly different compared with the unaffected side (p = 0.001; Table 3).

DISCUSSION

Modern neurosurgical techniques enable early intervention in cases of OBPL in infants with incomplete recovery within the first 3 to 6 months of life and infants with a subtotal lesion. Magnetic resonance imaging has been introduced to visualize the plexus lesion. This modality is also suitable for visualizing the early secondary shoulder deformities that may be present in some infants. This is confirmed in the present study, revealing the secondary deformities of cartilaginous structures of the shoulder in

TABLE 2
Summary of neuroimaging findings*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (mos)</th>
<th>Sex</th>
<th>Group</th>
<th>Affected Side</th>
<th>Glenoid Version ‡</th>
<th>Humeral Head Sublux (˚)§</th>
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<tbody>
<tr>
<td></td>
<td>at MRI,</td>
<td></td>
<td>Narakas</td>
<td>Affected Side</td>
<td>Glenoid Form†</td>
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* Sublux = subluxation.
† Glenoid form: 1, concave-flat; 2, convex; 3, biconcave.
‡ Glenoid version according to Friedman, et al.
§ Humeral head subluxation according to Papilion and Shall.

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most within the first 14 months of life. We found in the majority of infants 5 months of age and older that the glenoid form is abnormal, glenoid version is altered, and humeral head subluxation is present. In our study, a substantial number of patients were selected to undergo imaging because of a persistent neurological deficit; however, we think that secondary shoulder deformities are not limited to patients with such a severe type of OBPL. This rationale is supported by Fairbank, who reported shoulder deformities in 28 children in a consecutive group of 37 OBPLs involving all types of brachial plexus lesion. In addition, the authors of two recent studies reported a persistent internal rotation contracture of the shoulder in most infants with OBPL in whom there was a delay of more than 2 months in biceps muscle recovery.9,18

We found no evidence to support the hypothesis of some authors that secondary shoulder deformities in OBPL are caused by a fracture of the proximal humeral epiphysis, which leads to an increased humeral head retroversion.14,20 The clinical relevance of the shoulder deformities is still unclear. Are these deformities adaptations of skeleton to the altered muscular function due to the complete or incomplete OBPL and, as such, compensatory mechanisms? Alternately, are the deformities dysfunctional and responsible or partly responsible for loss of function in some children? Perhaps there is no clear answer but deformities may differ in their role in different children. In our view these deformities alone are seldom entirely responsible for clinical symptoms.

CONCLUSIONS

Our findings indicate that because MR imaging reveals both damage to the nerve roots and the anatomy of the shoulder, MR imaging allows evaluation of the neural, osseous, and cartilaginous structures in the younger child. Accordingly, MR imaging studies of both shoulder and cervical spine should routinely be performed in one session in patients being considered for neurosurgical intervention. Early detection of shoulder deformities is possible and thereby opens possibilities for new types of treatment.

References


TABLE 3

Quantitative measurements of shoulders*

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>&lt;5 Mos Old</th>
<th>≥5 Mos Old</th>
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<tbody>
<tr>
<td>Affected Side</td>
<td>Healthy Side</td>
<td>p Value</td>
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<tr>
<td>Glenoid version</td>
<td>−9°</td>
<td>−7°</td>
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<tr>
<td>Amount of sublux</td>
<td>160°</td>
<td>169°</td>
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</table>

* NS = not significant.
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