Assessment of Children With Brachial Plexus Birth Palsy Using the Pediatric Outcomes Data Collection Instrument

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Abstract: The purpose of this study was to determine whether the Pediatric Outcomes Data Collection Instrument (PODCI) measures differences in function between children with brachial plexus birth palsy (BPBP) who are candidates for shoulder tendon surgery and age-matched controls. The PODCI was administered prospectively to 23 children with BPBP who were candidates for shoulder tendon surgery. Their results were compared with published PODCI data for control subjects, and factors associated with function within the BPBP cohort were determined. Children in the BPBP cohort had significantly lower PODCI scores in upper extremity function, sports, and global function than control subjects. Limited active shoulder external rotation was significantly associated with lower functional scores. The PODCI measures diminished upper extremity function in children with BPBP who are candidates for shoulder tendon surgery, thereby showing promise as a tool for measuring baseline function and postoperative functional gains for children with BPBP.

Key Words: brachial plexus birth palsy, outcomes measures, Pediatric Outcomes Data Collection Instrument (PODCI), shoulder, tendon transfer

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The Pediatric Outcomes Data Collection Instrument (PODCI) was developed in 1994, through the combined efforts of the American Academy of Orthopaedic Surgeons, the American Academy of Pediatrics, Shriners Hospitals for Children, and the Pediatric Orthopaedic Society of North America, to provide a standardized outcome assessment of pediatric musculoskeletal conditions. It obtains semi-quantitative, patient- and parent-reported measures of function and quality of life with respect to several domains: mobility and transfers, upper extremity (UE) function, ability to participate in sports, comfort or pain, and happiness. A global function score is derived from the first four domains. The instrument has been validated (except for the happiness domain),[1–3] and normative values for children without musculoskeletal limitations have been published.[4,5] However, before the PODCI can be used to understand the extent of perceived limitations and measure the success of treatment of children with a specific musculoskeletal disorder such as brachial plexus birth palsy (BPBP), it must be proven to reliably differentiate children with BPBP who are candidates for reconstructive surgery from children without a musculoskeletal disorder.

BPBP occurs in 0.5 to 1 per 1,000 live births.[6–9] Disability resulting from BPBP varies from mild, partial, and transient UE weakness to complete, permanent UE paralysis, with an estimated 80% of affected newborns regaining full or near-full function.[10–13] Erb's palsy, or injury to the upper trunk where the C5 and C6 nerve roots join and the suprascapular nerve originates, is the most common type of BPBP and has the best prognosis for recovery. However, children with upper trunk BPBP often have residual weakness of shoulder external rotation and abduction, causing difficulty throwing, climbing, or reaching their hand to their face or head. For children with well-preserved passive shoulder range of motion (PROM) and good deltoid strength, surgery that combines lengthening of shoulder internal rotator(s) and external rotation tendon transfers improves shoulder muscle balance, active range of motion (AROM), and possibly glenohumeral articular congruence.[14–21] Despite these reports of improvement in shoulder motion and muscle balance, it is not known whether improved active shoulder ROM correlates with patient-perceived functional gains.

The purposes of the present study were to determine, as measured by the PODCI, the baseline function of children with BPBP who are candidates for shoulder tendon surgery (lengthening of the internal rotator(s) and external rotation tendon transfers, or ERTT surgery); to compare it with normative data from children without musculoskeletal limitations and children from the general population (control cohort); and to determine factors associated with lower functional scores in the ERTT cohort. Ultimately, we plan to use this information to reliably evaluate the function of children with BPBP and the effects of interventions such as ERTT.

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MATERIALS AND METHODS

This study is part of an ongoing prospective longitudinal study of children evaluated and treated for BPBP at Shriners Hospitals for Children Northern California (SHCNC). This study was approved by the Institutional Review Board of University of California Davis Medical Center, and informed consent was obtained from the parent or legal guardian of each child enrolled in the ERTT study group.

Children presenting to the BPBP clinic at SHCNC between May 2000 and May 2002 were candidates for this study. During the study period, the BPBP clinic at SHCNC had 698 visits. Each child underwent evaluation by the same pediatric UE surgeon (M.A.J.), who determined whether he or she was a candidate for ERTT. Indications for ERTT included upper trunk BPBP with parent- or child-perceived functional deficit associated with deficient (usually absent) active shoulder external rotation, active shoulder abduction of at least 60 degrees, no glenohumeral dislocation on axillary radiograph, and ability to follow a postoperative exercise program (as determined by preoperative consultation with an experienced pediatric occupational therapist). Children with BPBP who were not surgical candidates were excluded from this study. Children with BPBP who were ERTT candidates but whose families did not speak English were also excluded (because the PODCI has not been validated through the use of a translator, and a validated Spanish version was not available).

Between May 1, 2000, and May 31, 2002, 33 children underwent ERTT at SHCNC, and 23 children met the criteria for this study and are included in the ERTT cohort. Demographic data for the 23 subjects in the ERTT cohort are presented in Table 1.

For children aged 2 to 10 years, the PODCI is administered to the child's parent; all children in the ERTT cohort were under age 9 years. For each subject, the functional dimensions assessed by the PODCI 114-item questionnaire were collected, including UE function, transfers and basic mobility, sports and physical function, comfort/pain, happiness with physical condition, and global function (which is an average of the UE, mobility, sports, and comfort scales). Scores for each of the five primary dimensions within the PODCI are scaled from 0 to 100, with 100 being the highest level of function, happiness, or comfort. The mean PODCI scores in each dimension were compared with previously published normative values for children under age 11 years. Two sets of normative parent-respondent PODCI values were used for comparison with our cohort: the American Academy of Orthopaedic Surgeons (AAOS)-published normative values of over 1,700 children aged 2 to 10 years as collected from a random sample of the general population,[5] and another study of parent-reported PODCI results for 29 children aged 2 to 10 years who were free from musculoskeletal limitations.[4]

TABLE 1. ERTT Cohort Characteristics (n = 23)

Female gender (n)	14	(61%)
Age (years)	5.6	(3.5–8.6)
Right side affected (n)	10	(43%)
Comorbidities (n)*	10	(43%)
Mean shoulder external rotation in 90° abduction†	17°	(0–70°)
Shoulder abduction†	112°	(60–165°)
Elbow ROM†	116°	(65–150°)
Hand involvement (global BPBP) (n)	1	(4%)
Supination contracture (n)	3	(13%)

*See text for details.
†Range of motion values are given as active range of motion during the preoperative assessment.

For each subject in the ERTT cohort, baseline information including age, gender, and non-musculoskeletal comorbidities were recorded. In the PODCI, information about comorbidities is obtained by three questions regarding each of 16 conditions (juvenile arthritis [one or two joints]; juvenile arthritis [many joints]; anorexia or bulimia; asthma; attention or behavioral problems; chronic allergies or sinus trouble; developmental delay; mental retardation; diabetes; epilepsy; hearing impairment or deafness; heart problem; learning problem; sleep disturbance; speech problems; vision problems), including whether the child has ever had the condition and, if so, whether he or she is being treated for it now; and whether the condition limits his or her activities. Thus, there are 48 possible "yes" answers to the PODCI comorbidity questions, and the PODCI comorbidity score is the number of "yes" answers divided by 48 and multiplied by 100. If a child is currently under treatment of one condition that limits his or her activities, the comorbidity score will be 3/48 or 6; if a child has had two different comorbidities that are not currently being treated and that do not limit his or her activities, the comorbidity score will be 2/48 or 4.

The PODCI was administered by computer, in touch-screen format, with the assistance of research staff. In addition to PODCI administration, the active ranges of shoulder abduction, shoulder external rotation in adduction and abduction, active and passive elbow motion and forearm rotation, and the presence or absence of hand involvement were all measured for each subject at the time of PODCI administration. These factors were assessed in a separate analysis intended to ascertain predictors of function as reported by the PODCI within the ERTT population.

Comparisons of mean PODCI scores between normative values and the ERTT cohort were performed using an unpaired, two-tailed Student *t* test for each dimension within the PODCI, with the significance level set at $P < 0.05$. Assessment of factors associated with lower PODCI scores within the ERTT cohort was performed with both univariate and stepwise multivariate regression analysis. The chi-square test was used for univariate analysis of categorical variables (side of involvement, gender, presence of hand involvement, and presence of supination contracture).

RESULTS

PODCI Scores for ERTT Cohort Versus Normative Groups

The average age of the 23 children in the ERTT cohort, 5.6 years, did not differ significantly from the average age of children in the Houston normative group, which was 6.3 years ($P = 0.17$; age data provided by Haynes and Sullivan, personal communication). The age of the AAOS normative children ranged from 2 to 10 years.

Table 2 summarizes the mean PODCI scores for the three cohorts for each functional domain. The ERTT cohort had significantly lower functional scores with respect to UE function than the Houston normative population and the AAOS general population. Mean sports and global function scores were also significantly lower in the ERTT cohort compared with previously published normative values for children. Statistical significance persisted after controlling for measured comorbidities in the ERTT cohort. Although mobility/transfer scores were significantly lower in the ERTT cohort than the Houston normative value, the difference between the ERTT cohort and the AAOS general population for scores in this domain was not statistically significant. There were no statistical differences between the ERTT cohort and controls with respect to comfort or happiness as measured by the PODCI.

Assessment of Associated Factors

Within the ERTT cohort we compared the PODCI scores for each domain with demographic characteristics, including age, gender, and hand dominance; PROM and AROM for the affected shoulder, elbow, and forearm; type of BPBP (upper vs. global); and the non-musculoskeletal comorbidity score. Of the factors studied, none was significantly associated with PODCI UE or sports function within the ERTT cohort. Forty-three percent (10/23) of the patients in our cohort reported non-musculoskeletal comorbidities on the PODCI (Table 3). Non-musculoskeletal comorbidities were significantly associated with lower PODCI mobility/transfer scores. The statistically significant relationship between lower mobility/transfer scores and increasing severity of comorbidities remained after controlling for other factors in a multivariate, stepwise regression analysis. Higher values of reported comorbidity were also associated with statistically lower levels of comfort.

Among the ERTT cohort, all children had diminished or absent active shoulder ER in abduction as an indication for ERTT (Table 1). When the amount of retained active shoulder ER in abduction was compared with comfort scores, higher active ER in abduction was associated with higher levels of comfort. Only increasing severity of comorbidity remained statistically associated with reported comfort scores after controlling for other factors in a stepwise multivariate regression analysis.

The global function score is based on an aggregate score of the PODCI dimensions, excluding the happiness dimension. Within the ERTT cohort, the severity of comorbidity as measured on the PODCI was correlated with lower global function PODCI scores.

The normative values from the AAOS and the Houston study do not mention an assessment of comorbidities among their "normative" populations. To eliminate the possibility that comorbidities could be a variable confounding the difference between the ERTT cohort and the published normative values, we subsequently stratified our cohort into 13 children without reported comorbidities and 10 children with reported comorbidities. There was no significant difference between these two small groups with respect to mean function in any of the PODCI domains. There remained a significant difference between both of these groups and controls with respect to UE, sports, and global function domains; thus, it is unlikely that comorbidities are confounding variables in the comparison of our ERTT cohort with published normative populations.

DISCUSSION

The PODCI is well-validated outcomes tool that is easy to administer, especially in the computerized touch-screen format used for this study. It has only recently been used to measure differences between children with orthopaedic conditions and normal controls as part of an ongoing effort to establish the level of functional impairment associated with different orthopaedic conditions.[22] Prior to determining whether an intervention such as surgery improves function, it is important to establish a reproducible and valid assessment of pretreatment function. The PODCI provides this for children with BPBP who are candidates for ERTT, and the present study illustrates that the functional deficits of these children are measured by this instrument.

TABLE 2. Comparison of Mean PODCI Scores Between the ERTT Cohort and Published Normative Values

	SHCNC BPBP Cohort Palsy (n = 23)		Houston Study Normals[4] (n = 29)			AAOS Normals[5] (n = 1,700)		
Measure	Mean Score	Standard Deviation	Mean Score	Standard Deviation	*P* Value	Mean Score	Standard Deviation	*P* Value
UE†	76.7	11.3	95.8	9.0	**<0.001**	92.0	11.5	**<0.001**
Mobility	96.6	5.7	99.0	2.6	**0.044**	98.4	5.7	0.160
Sports*	84.4	10.9	91.8	12.2	**0.026**	90.2	12.3	**0.017**
Comfort	90.7	16.7	92.0	19.3	0.797	92.4	13.8	0.614
Happiness	84.4	17.9	86.8	19.6	0.675	89.8	14.1	0.180
Global Function†	87.1	8.8	94.6	7.1	**0.001**	93.3	7.8	**0.003**

P values are derived from two-sided t-tests of the mean PODCI score when comparing the ERTT cohort with each set of normative values. Bolded *P* values are statistically significant ($P < 0.05$).

*$P < 0.05$ when the mean scores of the BPBP cohort are compared to the Houston normative[6] and the AAOS normative[9] values.

†$P < 0.01$ when the mean scores of the ERTT cohort are compared to the Houston normative[6] and the AAOS normative[9] values.

TABLE 3. Children With Reported Comorbidities in ERTT Cohort (n = 10)

Pt. No.	Age (Years)	Gender	Impairment	Comorbidity Score
1	5	F	Asthma	2
2	4.5	M	Asthma	4
3	5	M	Asthma/speech	4
4	7.5	F	Asthma/vision	10
5	7.5	M	Attention/behavior	4
6	4	F	Developmental delay/speech	8
7	6.5	F	Cardiac/vision	4
8	8.5	F	juvenile arthritis	2
9	4.5	F	Juvenile arthritis/allergic condition/developmental delay	19
10	5.5	M	Learning disability/speech	12
Average comorbidity score				6.9

This report quantifies the baseline functional status of children with BPBP who are candidates for ERTT and compares it with published normative data from children free of musculoskeletal limitations. It shows that the PODCI measures clear differences between children with BPBP and normal children with respect to UE, sports, and global function. Additionally, the ERTT cohort had significantly lower mobility scores than normative values in the Houston study.[4] There was no measurable difference between the ERTT cohort and controls with respect to comfort or happiness.

Within the ERTT cohort, an increasing magnitude of reported comorbidities was associated with a detrimental effect on function in the areas of comfort, mobility, and global function. There was no association within the ERTT cohort between additional comorbidities and UE function or happiness, suggesting that identification and assessment of the role(s) of non-musculoskeletal comorbidities may be an important component of functional assessment when using the PODCI. Some factors that would be expected to be associated with poorer function in this group, such as supination contracture or global involvement, occurred too infrequently in this study population to allow analysis of their effect on function. However, because PODCI comorbidities are identified by the parent or adolescent, they cannot be considered as reliable as diagnoses made by a physician.

Higher active range of shoulder ER in abduction (the motion needed to reach the head and face and to throw or climb) within the ERTT cohort was associated with a higher comfort score, or less pain as measured by the PODCI. These associations may indicate that interventions aimed at improving active shoulder ER, such as ERTT, could improve comfort as reported on the PODCI. To adequately evaluate this hypothesis, a study comparing preoperative with postoperative PODCI scores in this same population and correlating PODCI scores with objective improvement in range of motion postoperatively would be necessary. Trends toward a positive relationship between active ER in abduction and comfort, mobility/transfers, and global function remained after controlling for other factors, but these associations did not reach statistical significance. No other measured variables reached statistical significance on either univariate or multivariate analysis.

One limitation of the parent-reported PODCI is that the functional outcome of interest is reported through a surrogate respondent, in this case the parent. Hunsaker et al[5] raised this issue, stating "one might anticipate greater variability for responses that estimate another person's functional status. Parents are more likely to overestimate or underestimate their child's physical functioning capabilities." Additionally, young children may vary in their ability to perform tasks reflected in the PODCI functional dimensions. Despite these limitations of the parent-respondent functional scales, the PODCI meets rigorous reliability and validity criteria for use as an outcome measure in children aged 2 to 10.[5] The strength of the findings in the current study lie in the statistically significant functional deficits reported by parents of children with BPBP who are candidates for ERTT when compared with normative data from two populations: a group of children free from musculoskeletal affliction,[4] and a large sample of children from the general population whose health status and level of musculoskeletal disease are unknown.[5]

This study assesses the baseline, preoperative function of a cohort of children with BPBP who have been determined to be candidates for ERTT by standard clinical indications. This group of children has measurable functional limitations, most profoundly UE functional deficits, compared with control values from the literature. This study shows that the PODCI can measure functional differences between these children and controls, and quantifies these functional differences. These results will serve as a baseline for documenting the efficacy of ERTT in improving function for children with BPBP.

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