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Prevalence of head deformities in preterm infants at term equivalent age ☆

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ABSTRACT

Introduction: Due to a rising number of head deformities in healthy newborns, there has been an increasing interest in nonsynostotic head deformities in children over recent years. Although preterm infants are more likely to have anomalous head shapes than term newborns, there is limited data available on early prevalence of head deformities in preterm infants.
Aims: The purposes of the present study were to acquire quantitative data on head shape of preterm infants at Term Equivalent Age (TEA), to determine the prevalence of symmetrical and asymmetrical head deformities and to identify possible risk factors.
Methods: In a cross-sectional study design, Cranial Vault Asymmetry Index (CVAI) and Cranial Index (CI) calculated from routine head-scans with a non-invasive laser shape digitizer were recorded and categorized in type and severity of deformation for three different groups of gestational age. Perinatal and postnatal patient data was tested for possible associations.
Results: Scans of 195 infants were included in the study. CVAI at TEA was higher in very preterm (4.1%) compared to term and late preterm infants. Prevalence of deformational plagiocephaly was 38% in very preterm infants. CI was lower in very (71.4%) and late (77.2%) preterm infants compared to term infants (80.0%). Compared to term babies (11%), a large number of very (73%) and late (28%) preterm infants exhibited dolichocephaly at TEA.
Discussion: Prevalence of symmetrical and asymmetrical head deformities in preterm infants is high at TEA. Interventions are required to prevent head deformities in preterm infants during the initial hospital stay.

1. Introduction

There has been an increasing interest of researchers and clinicians in nonsynostotic head deformities in children over recent years since a rising number of head deformities even in healthy newborn babies have been reported [1–5]. Head deformities are not only a cosmetic problem but may serve as a marker for an increased risk of developmental delay [6–8]. Thus, not only identification of risk factors but also early and accurate detection of head deformities is required.

Head deformities can be divided into abnormal proportion of cranial length and width (symmetrical deformities) and disturbed cranial symmetry (asymmetrical deformities). While deformational plagiocephaly (DP) and brachycephaly are commonly described in term newborns [3–5], cranial narrowing or dolichocephaly has been reported over decades by different authors as a specific head deformity of the preterm infant [9–11].

Several authors suggest the Cranial Vault Asymmetry Index (CVAI) and the Cranial Index (CI) as quantitative measures of head shape [12,13]. CVAI provides information on cranial symmetry, while CI is describing proportion of cranial width to length. Wilbrand and coworkers recently provided normative percentiles for CVAI, CI and other anthropometric cranial measurements in the first year of life and suggested categorization of brachycephaly and plagiocephaly into mild, moderate and severe forms [13]. This may allow better classification and follow-up of head deformities.

Although classification is possible, head shape quantification is still not standardized and cranial deformities are often only assessed by clinical and visual impression. The accuracy of visual analysis and clinical assessment with anthropometric caliper measurements is controversial [14,15]. Therefore, other techniques have been recently described to improve the assessment of head deformities [16–19]. Evaluation of cranial asymmetry based on digital photography is a simple and accurate

Abbreviations: 3D, Three-Dimensional; BPD, Bronchopulmonary Dysplasia; CI, Cranial Index; CPAP, Continuous Positive Airway Pressure; CS, Cesarean Section; CVAI, Cranial Vault Asymmetry Index; DP, Deformational Plagiocephaly; GA, Gestational Age; HC, Head Circumference; ICH, Intracranial Hemorrhage; IMC, Intermediate Care; IMV, Invasive Mechanical Ventilation; IQR, Interquartile Range; Max, Maximum; Min, Minimum; NEC, Necrotizing Enterocolitis; OR, Odds Ratio; PMA, Postmenstrual Age; TEA, Term Equivalent Age.

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noninvasive method; however, it is based on a two-dimensional approach [16]. In contrast, three-dimensional (3D) quantitative information on head shape can be obtained with a noninvasive laser shape digitizer and stereo camera system [18–20].

In term healthy infants, the supine sleeping position, maternal [21], prenatal [22–24] and perinatal risk factors [25] as well as postnatal issues such as specific nursing habits have been identified as factors associated with the subsequent development of head deformities [26]. Developmental delays may further inhibit normal changes of positioning the head during rest, leading to an increased risk of developing head deformities [24]. Early neonatal head shape abnormalities such as localized flattened areas are considered to be precursors to posterior DP. In term infants, localized cranial flattening and other head shape abnormalities have already been described in the first days of life, where incidence in singletons was 13% [27].

Preterm infants are at particular risk of developing head deformities. Prematurity has previously been described as a risk factor for symmetrical and asymmetrical cranial deformation [9,10,24]. Due to malleable cranial bones, preterm infants might be more susceptible for cranial molding [28,29]. Since head deformities may serve as a marker for developmental delay and preterm infants are also known to be at risk for adverse neurodevelopmental outcomes [30–32], accurate monitoring of head shape could be useful especially in preterm infants.

However, the prevalence of head deformities in premature babies in the early postnatal period and at term-equivalent age (TEA) is still unknown. Early recognition of head deformities may have the potential to alert parents and caregivers and help to initiate simple measures such as changing the crib position regularly and allowing supervised "tummy time" while infant is awake. Furthermore, early diagnosis of head deformities might be useful for the postnatal follow-up of high-risk patients, since head deformities may serve as a marker of developmental risk [6].

1.1. Aims of the study

The purposes of our study were to acquire quantitative data on head shape of preterm infants at TEA, to determine the prevalence of symmetrical and asymmetrical head deformities and to identify possible risk factors.

2. Materials and methods

2.1. Study design

Preterm infants discharged from an intermediate care (IMC) unit of a tertiary neonatal clinic in Dresden, Germany from April 2011 to January 2013 were included in a cross-sectional study design. Three-dimensional head shape scans were performed weekly as part of the clinical routine at the IMC unit. All infants were included that were present on the ward at the time of measurement. Excluded were those with peripheral IV at the scalp and those requiring supplemental oxygen. The pre-discharge scan of each infant was analyzed, if it was performed at TEA (37–40 weeks of gestation).

2.2. Head shape data acquisition

Cranial measurements were made using a non-invasive laser shape digitizer (STARScanner, Orthomerica, Orlando, FL, USA) as previously described [19]. The device captures a three-dimensional infant head shape using four Class-I eye-safe lasers. It has received clearance from the FDA and conforms to European Standards and technical specifications for this use. It has previously been tested for accuracy and reliability and produced consistent measurements with inter-operator differences of less than 1 mm [19,20]. Patient preparation and procedure have been described in detail earlier [19]. In short, infants were placed in the scanner for about 20 s. The scanning process lasts about 3 s, during which time the infant should not move. Scans were incorporated into specialized software (YETI™ Shape Builder, Vorum Research Corporation, Vancouver, Canada). Sellion and each tragion were used as anatomical landmarks for building a reference plane and subsequent calculations. The cranium was divided into twelve proportionally spaced cross-sections parallel to the reference plane. Cross-section 3 was used to measure biparietal diameter, fronto-occipital diameter and 30° diagonals since it closely reflects the level of maximum frontal–occipital extension (Fig. 1).

CI [biparietal diameter / fronto-occipital diameter × 100] and CVAI [(diagonal A − diagonal B) / diagonal A × 100, where diagonal A > diagonal B] were calculated to describe head shape and distinguish between symmetrical (brachycephaly, dolichocephaly) and asymmetrical (plagiocephaly) head deformities. Normative percentiles by Wilbrand and coworkers for healthy infants at up to three months of age were used for a 3-level severity categorization of the deformity. Brachycephaly was defined as high CI and therefore shorter head shape relative to the mentioned data; plagiocephaly was defined as high CVAI relative to the reference values [13]. While Wilbrand and coworkers did not describe cranial narrowing, we classified dolichocephaly as mild (CI = 10th to 25th percentile), moderate (CI = 3rd to 10th percentile) and severe (CI < 3rd percentile) according to their data.

2.3. Patient data acquisition

Descriptive data were obtained from patient records including gestational age (GA), gender, weight, head circumference (HC) and length at birth as well as postmenstrual age (PMA), weight, HC and length at the time of measurement. Additionally, perinatal data (mode of delivery, birth presentation) were collected. Data on neonatal morbidity were also recorded: presence of Bronchopulmonary Dysplasia (BPD) [33], Necrotizing Enterocolitis (NEC) [34], Intracerebral Hemorrhage (ICH) [35] and durations of total respiratory support, Continuous Positive Airway Pressure (CPAP) and invasive mechanical ventilation (IMV) respectively.

2.4. Ethics statement

Ethical approval was given by the ethics committee of the Medical Faculty Carl Gustav Carus of the Technical University Dresden, Germany (EK 261082012). As infants received standard care and routine measurements with approved devices, data collection was considered an audit of normal care. As only anonymized data was collected, the ethics committee waived the need for specific parental consent.

2.5. Statistical methods

Data were analyzed and charted using GraphPad Prism version 5.0 for Windows/Mac OS (GraphPad Software, San Diego, CA, USA) and Microsoft Excel 2011 (Microsoft Corp., Redmond, WA, USA). Medians, Interquartile Ranges (IQR), Minimum (Min) and Maximum (Max) of CI and CVAI were computed and displayed in boxplot diagrams and compared using Mann–Whitney test. Statistical significance was assumed at $p < 0.05$. Categorical data was compared using contingency tables and Fisher's exact test with two-tailed p-value. In the second step, possible risk factors were analyzed categorizing preterm infants as controls or cases (moderate to severe head deformity). Odds Ratios (OR) and p-values were calculated using Fisher's exact test.

3. Results

3.1. Cohort characteristics

Of the 1240 patients who were treated on the unit between 04/2011 and 02/2013, 758 patients were scanned with the 3D laser system at least once during the hospital stay. Excluded from the data analysis