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Skin breakdown of the feet in patients with spina bifida: analysis of risk factors

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Abstract

Purpose: Recent studies on patients with spina bifida have noted an increased incidence of skin breakdown with more proximal functional neurologic level. We hypothesized that there would be an inverse relationship between skin breakdown of the foot and severity of functional level of lesion, because patients with more caudal levels of lesion spend more time ambulating.

Methods: The National Spina Bifida Patient Registry (NSBPR) at Children's of Alabama was queried for the presence of skin breakdown of the foot, ambulatory status, functional neurologic level, and diagnosis of myelomeningocele (MMC) vs. non-myelomeningocele (non-MMC). Univariate and multivariate analysis were performed.

Results: Of 491 total patients, 378 were MMC and 113 were non-MMC. Eighty five of 378 (22.5%) patients with MMC and 5 of 113 (4.4%) non-MMC patients reported skin breakdown ($p = .009$). Thoracic and lumbar levels were compared to the sacral level for statistical analysis. Skin breakdown occurred in 26.2% of thoracic ($p=.001$), 33.3% of high-lumbar ($p=.001$), 21.5% of mid-lumbar ($p=.008$), 26.2 % of low-lumbar ($p=.001$), and 6.1% of sacral level patients. Ambulatory status was not significant on multivariate analysis.

Conclusion: A diagnosis of MMC is a significant, independent risk factor for skin breakdown of the foot. Compared to sacral level, thoracic and lumbar levels of function were also independently significant. Ambulatory status was not significant.

Keywords

Spina Bifida; skin breakdown; ambulation

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Introduction

Spina bifida is a neural tube defect that occurs in approximately 3.1 per 10,000 children and adolescents in the United States (1). Individuals with spina bifida may manifest impairments in mobility, sensation, bowel and bladder continence, and executive function. Skin breakdown is a common problem in individuals with spina bifida due to sensory and motor dysfunction (2,3,4,5,6,7,8). It can lead to infection, loss of function, amputation, and death. In addition, skin breakdown is associated with increased health care costs and is one of the most frequent causes of hospitalization in patients with spina bifida (9). Understanding factors associated with the development of skin breakdown may facilitate prevention. Recent studies (5, 7) that have explored factors associated with skin breakdown in all locations have noted an association of pressure ulcers with a more proximal functional lesion level. This is intuitive for skin breakdown involving the sacrum or ischium, since patients with more proximal levels of lesion are less likely to be ambulatory, spend more time sitting, and have greater sensory dysfunction.

Patients with spina bifida can be classified as myelomeningocele (MMC) and non-myelomeningocele (non-MMC) including fatty filum/tethered cord, split cord malformation/diastematomyelia, lipomyelomeningocele, and meningocele. Patients with MMC tend to manifest greater impairments in sensation and mobility and have been shown in previous studies to have a higher prevalence of skin breakdown compared with non-MMC patients (5, 10, 11). Multiple studies have also shown that age is a risk factor for skin breakdown (5, 7, 13). To date, no studies have explored the relationship of foot shape or history of previous foot surgery to skin breakdown of the foot in spina bifida, though Kim et al. noted an association of orthopedic surgery above the knee with overall skin breakdown (5).

The present study was designed to evaluate factors associated with skin breakdown of the foot. Specifically, we hypothesized that skin breakdown of the foot would be more common in ambulatory patients or those with more distal levels of neurologic function due to weightbearing forces. We also explore whether diagnosis (MMC vs. non-MMC), history of orthopedic surgery of the foot, and foot shape (plantigrade vs. non-plantigrade) are associated with skin breakdown of the foot.

Methods

All individuals seen at the Children's of Alabama (COA) multidisciplinary Spina Bifida Clinic between March 2009 and September 2016 were identified using the electronic medical record (EMR). Children with a diagnosis of spinal dysraphism, including myelomeningocele (MMC), meningocele, split cord malformation, lipomyelomeningocele, and dermal sinus tract attend the Spina Bifida Clinic. With informed consent, patients attending the clinic are enrolled in the National Spina Bifida Patient Registry (NSBPR).

The NSBPR collects data through a form to be used for comparison purposes. The data are collected longitudinally. The patients are given a unique identifying number so that their data can be tracked and accumulated over a period of time. These data points are designed to track demographics, treatment methods, and outcomes in order to support the development

of evidence-based best practices. Each patient seen in the COA clinic is approached to be included in the NSBPR. Currently, greater than 99% of our total patient population is enrolled in the NSBPR. Since both MMC and non-MMC diagnoses were investigated, no patients were excluded except those that did not participate in the NSBPR.

Data Collection

During the clinic visit, each participant and their parents/caregivers are interviewed and asked a standard set of questions from the NSBPR. All NSBPR variables are recorded at that time and entered into the NSBPR EMR. Included in these questions is information regarding skin breakdown in the previous 12 months. The data also includes the location of the skin breakdown, the suspected cause of the skin breakdown, and whether the incidence of skin breakdown has been previously reported (i.e., for breakdown that has lasted longer than 12 months). The research team at COA verifies the information obtained from the patient/caregiver with the hospital medical record. Through this process, information obtained during the patient interview is compared to the hospital medical record and the information obtained through the hospital record is also recorded. If discrepancies appear between the patient interview and the medical record, these are reconciled to the extent possible prior to NSBPR data entry. For the purposes of this study, skin breakdown was not sub-divided into pressure or other causes, and all participants who reported skin breakdown on the foot were included.

For each participant, the following data points were retrieved from the NSBPR EMR: age, gender, primary diagnosis (open MMC, lipomyelomeningocele, diastematomyelia, other), race (white, black, other), ethnicity (Hispanic or Latino versus non Hispanic or Latino), ambulation status (ambulates in the community, ambulates only within the home, ambulates only during organized therapy, or non-ambulatory), functional level of lesion (thoracic [no motor function in lower extremities], high-lumbar [hip flexion present], mid-lumbar [knee extension present], low-lumbar [foot dorsiflexion present], sacral [foot plantarflexion present]), and presence of skin breakdown (yes versus no, if yes select location [head/neck, upper extremity, lower extremity, trunk, posterior pelvis, perineum, foot]). We also collected any history of orthopedic foot procedures.

For patients with skin breakdown of the foot, a retrospective chart review of the COA medical record was performed by the treating orthopedic surgeon to delineate foot shape, which was graded as either plantigrade or non-plantigrade. Also, a history of previous surgery on the foot was noted.

Statistical Analysis

First, descriptive Chi-square tests and univariate logistic regression were utilized to analyze relationships between skin breakdown on the foot, functional level of lesion, and ambulation status. To test for independent association between skin breakdown of the foot and the predictive variables, a multivariate logistic regression model was constructed, including those variables with a p value less than 0.2 on univariate analysis. Associations with $p < 0.05$ on multivariate analysis were regarded as significant. SPSS Version 23 (IBM Corp. Released

2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) was used for all statistical analyses.

Results

There were 491 total patients enrolled in the NSBPR at the Children's Hospital of Alabama, of which 97 (20.5%) reported having at least 1 foot skin breakdown in the 12 months before the time of their visit (Table 1). Of the 491 total patients, 378 carried a diagnosis of MMC and 113 were non-MMC. Eighty-five of 378 (22.5%) MMC and 5 of 113 (4.4%) non-MMC patients reported skin breakdown of the foot ($p = .009$). In regards to neurologic level, skin breakdown occurred in 26.2% of thoracic ($p=.001$), 33.3% of high-lumbar ($p=.001$), 21.5% mid-lumbar ($p=.008$), 26.2 % of low-lumbar ($p=.001$) and 6.1% of sacral level patients (Table 1). Ambulatory status was not significant on multivariate analysis (Table 2). Of those patients with skin breakdown, foot shape was adequately described in the medical record in 86 patients. Sixty-six were noted to have non-plantigrade feet while 20 had plantigrade feet. Because information about foot shape was not recorded in children without skin breakdown, no further analysis was possible.

A multivariate model was created including diagnosis, functional lesion level, and ambulation status. Diagnosis and lesion level were both significantly associated with skin breakdown of the foot. For children with MMC, the odds ratio for skin breakdown was 3.75 (95% CI 1.39–10.11, $p=0.009$). Compared to sacral functional level, all higher levels showed significant increase in the odds of skin breakdown (all OR between 3 and 8, all $p<0.005$, see Table 2). Ambulation status was not independently significant.

A history of foot and/or ankle surgery was noted in 52 patients. However, it was not possible to determine a relationship between skin breakdown and surgery as the NSBPR did not specify either the sidedness of the breakdown or the timing of foot surgery in relationship to the breakdown.

Discussion

The annual rate of overall skin breakdown in patients with spina bifida is between 15% and 77% (2,3,4,5,6,7,8). A recent study evaluating pressure ulcers in all locations reported an annual rate of 19% (5). The rate in the present study of 20.5% for the foot alone is a cumulative and not an annual rate and is consistent with previous studies.

Ottolini et al. noted the foot as the most common location for skin breakdown. They also noted an increased rate of foot skin breakdown in those with lower lumbar level lesions but did not discuss this further (7). The present study was conducted in order to verify our hypothesis that feet in ambulatory patients with lower levels of lesion would be more likely to develop skin breakdown. Contrary to both our initial hypothesis and the findings of Ottolini et al., skin breakdown of the foot was relatively evenly distributed across lumbar and thoracic levels but decreased precipitously at the sacral level. Though the NSBPR functional level of lesion is based on motor function, this should closely reflect sensory level. Since the plantar surface of the foot receives sensory innervation at a sacral level, the present data would seem to indicate that functional neurologic level (and perhaps by

extension sensory level and not ambulatory status) may be the more important factor in the development of foot skin breakdown. In fact, in the present study ambulatory status appeared to be significant on univariate analysis, but was not shown to be so on multivariate analysis.

The present study also noted a significant difference in the rate of skin breakdown of the foot in the MMC vs. non-MMC patients. This is consistent with the findings of Kim et al. (5), and is to be expected considering that non-MMC patients typically have less severe motor and sensory dysfunction.

The present study was not designed to determine the role of foot shape in the development of skin breakdown. Further delineation of this issue would require evaluation of foot shape in individuals who did not develop skin breakdown in order to determine the proportion of non-plantigrade feet in that population. Nevertheless, there were a high proportion of non-plantigrade feet in those with skin breakdown. Current practice does not support corrective foot surgery in patients with high levels of lesion who are non-ambulatory. However, if foot shape is indeed a factor in the development of skin breakdown, then it may be important to correct foot deformities even in those with upper lumbar or thoracic level lesions who may not otherwise require plantigrade feet for ambulation. This finding could be an important contribution in the prevention of skin breakdown of the foot in MMC and non-MMC.

Limitations of the study include the retrospective nature, which may be subject to recall bias (14). Nevertheless, the participants were typically interviewed annually during their clinic visit and parental recall was queried to determine the presence or absence of skin breakdown within the last 12 months. As patients with spina bifida may have difficulties with executive function, both patients and parents/caregivers are queried during the NSBPR data collection process. Selection bias would not be a problem in regards to those choosing to participate in the NSBPR, since the COA spina bifida clinic enrolls greater than 99% of patients in the NSBPR. Some bias may occur in regard to which patients within our catchment area choose to receive care in the COA spina bifida clinic. We would postulate that very few spina bifida patients in the state are receiving care outside of the COA clinic, as there are no other pediatric neurosurgery providers in the state of Alabama. However, our experience may not be representative of a national sample.

In conclusion, diagnosis of MMC and functional lumbar neurologic level or above were both found to be significant risk factors for skin breakdown of the foot. Future studies should focus on the influence of foot shape on skin breakdown and determining whether interventions such as a targeted bundle (e.g., the CDC skin care initiative “Did you look?”) directed at high-risk patients decrease the incidence of skin breakdown (15).

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Table 1.

Demographics, functional status of cohorts, and association with foot skin breakdown

	All patients (n=491)	Ever had foot skin breakdown (n=90)	No history of foot skin breakdown n (n=401)	P-value†
Age in years, mean	13±8 (range 7 months-35.2 years)			
Gender Female Male	259 (52.7%) 232 (47.3%)	44 (17%) 46 (20%)	214 (83%) 187 (80%)	0.44
Primary diagnosis Open myelomeningocele Non-myelo (closed Spina Bifida)	378 (77%) 113 (23%)	85 (23%) 5 (4.4%)	293 (76%) 108 (96%)	<0.001
Race White Black Asian Other	361 (74%) 75 (15%) 39 (7.9%) 16 (3.2%)	68 (19%) 16 (21%) 4 (10%) 2 (13%)	293 (81%) 59 (79%) 35 (90%) 14 (87%)	0.50
Ethnicity Not Hispanic or Latino Hispanic or Latino	447 (91.0%) 44 (9.0%)	87 (19%) 3 (6.8%)	360 (81%) 41 (93%)	0.039
Functional lesion level Thoracic (flaccid lower extremities) High-lumbar (hip flexion present) Mid-lumbar (knee extension present) Low-lumbar (foot dorsiflexion present) Sacral (foot plantarflexion present)	107 (22%) 33 (6.7%) 107 (22%) 65 (13%) 179 (37%)	28 (26%) 11 (33%) 23 (22%) 17 (26%) 11 (6.1%)	79 (74%) 22 (67%) 84 (78%) 48 (74%) 168 (94%)	<0.001
Independent ambulation Community ambulation Household ambulation Therapeutic ambulation Non-ambulatory	245 (51%) 30 (6.2%) 11 (2.3%) 199 (41%)	31 (13%) 10 (33%) 3 (27%) 46 (23%)	214 (87%) 20 (67%) 8 (73%) 153 (77%)	0.004
Foot Position and surgical history Plantigrade Non-plantigrade Ever had foot surgery		20 (21%) 65 (37%) Yes- 53 (54.6%)	Not recorded on patients without skin breakdown	* <i>Not calculated</i>

Student's t-test and logistic regression were used for comparison of means; Chi-square was used for comparison of proportions.

* p-values were not calculated for foot position and surgical history because timing on surgery and the presence of foot skin breakdown often overlapped. Foot position was also not always recorded.

Table 2

	Foot Pressure Sores		
	OR	95% CI	P-value†
Primary diagnosis Open myelomeningocele Closed spinal dysraphism	3.75 ref	1.39–10.11	0.009
Functional Level of Lesion Thoracic High-Lumbar Mid-Lumbar Low-Lumbar Sacral	5.85 7.57 3.39 4.53 ref	2.07–16.6 2.4–23.8 1.4–8 1.88–10.9 ref	0.001 0.001 0.005 0.001 ref
Independent ambulation Community ambulation Household ambulation Therapeutic ambulation Non-ambulatory	ref 1.49 0.74 0.58	ref 0.59–3.73 0.17–3.15 0.27–1.23	ref 0.402 0.68 0.155