A Comparison of the Braden Q and the Braden QD Scale to Assess Pediatric Risk for Pressure Injuries During Noninvasive Ventilation

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BACKGROUND: Noninvasive ventilation (NIV) masks are implicated in 59% of respiratory device-related pressure injuries in hospitalized children. Historically, the Braden Q scale was not adequate in identifying risk for pressure injury associated with devices and, therefore, was modified to the Braden QD scale. The purpose of this study was to evaluate whether the Braden QD scoring tool is better able to identify pediatric patients receiving NIV who are at risk for the development of pressure injury as compared to the previously used Braden Q scale. METHODS: This was a retrospective chart review of all pediatric subjects with NIV mask-related pressure injury. Demographics and Braden Q/Braden QD scores were extracted from the electronic health record at admission, at 48 h prior to pressure injury, at 24 h before injury, and at resolution. The scores were dichotomized into "no risk" or "at risk" score ranges on the basis of each scale's scoring parameters. The McNemar test was used to assess whether Braden Q and Braden QD have the same level of classification. RESULTS: Forty-five unique subjects, ages 1 m – 23 y with NIV mask-related pressure injury were identified (24 [53.3%] female; 21 [46.7%] male). Braden QD had a significant correlation with mask-related pressure injury at admission ($P < .001$), at 48 h prior to injury ($P < .001$), at 24 h prior to injury ($P < .001$), at time of injury ($P < .001$), and at resolution of the pressure injury ($P < .001$). The Braden Q score did not identify pressure injury at admission, at identification of pressure injury, nor at 24 h or 48 h prior to injury. CONCLUSIONS: No significant differences were found among groups in relationship to age or gender. 85% of the subjects identified as "at risk" with the Braden QD scale developed pressure injury; conversely, virtually all of the subjects with pressure injury were identified as "no risk" with the Braden Q scale. *Key words: pressure injury; pressure ulcer; pediatrics; bi-level; hospital-acquired pressure injury; skin; noninvasive ventilation; respiratory device-related pressure injury; Braden QD; Braden Q.* [Respir Care 2021;66(8):1234–1239. © 2021 Daedalus Enterprises]

Introduction

Hospital-acquired pressure injuries occur when the skin is compressed between a bony prominence and an external surface during hospitalization,[1-3] increasing the morbidity and mortality of patients.[4] Significant risk factors for pediatric pressure injuries include children with a history of pressure injury, extrinsic factors (eg, shear and moisture), intrinsic factors (eg, age, nutrition, hemodynamic factors, and the effect of mobility, activity, and sensory perception),[5] patients who were located in critical care or rehabilitation units, and those patients hospitalized in pediatric-specific facilities.[6] Respiratory devices deemed to place the child at risk are endotracheal tubes, face masks, nasal cannulas, oxygen saturation probes, tracheostomy tubes, and noninvasive ventilation (NIV) masks.[7] In 2019, hospital-acquired pressure injuries related to NIV masks accounted for 59% of medical device-related pressure injuries within the Children's Hospitals Solutions for Patient Safety data coalition "when classifying pressure injuries (stages 2, 3, 4, unstageable, and deep tissue injury by the following respiratory devices (CPAP/bi-level, nasal cannula, endotracheal tube-related, and tracheostomy-related)" (Solutions for Patient Safety Leadership, personal communication, January 14, 2020).

Pressure injury risk assessment tools were created to predict patients at higher risk for developing pressure injuries, but it is essential that tools perform well and offer good sensitivity and specificity.[8] Tools that accurately predict a high risk for pressure injury development can potentially direct more aggressive or more frequent interventions to prevent

pressure injury from occurring within this at-risk group.[8] The most frequently utilized pressure injury risk assessment tools in pediatrics are the Braden Q, Garvin, and Galmorgan

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scales. Anthony et al[9] reported that the Glamorgan scale was the most valid of these scales in pediatrics but did not specifically test for respiratory device-related pressure injuries.

The Braden Q score, developed by Quigley and Curley, is the only pressure injury risk scale validated for use in the pediatric ICU, and it is used widely within the United States; however, initial predictive validity testing only included immobility-related pressure injuries in critically ill patients.[8,10] Lauderbaugh et al[11] previously identified that the Braden Q score did not identify with pressure injuries in patients wearing NIV masks ($P = .76$). In 2018, a new scale for pediatrics, the Braden QD scale, was found to reliably predict both immobility-related and device-related pressure injuries in the pediatric acute care environment.[10]

The Braden QD scale, similar to the Braden Q scale, is composed of 7 subscales. The Braden QD was revised from the Braden Q, which was limited to predicting immobility-related pressure injuries. The new scale included mobility, sensory perception, friction and shear, nutrition, and tissue perfusion/oxygenation while replacing moisture and activity from the Braden Q scale with the number of devices (ie, attached to or traversing the patient's skin or mucous membranes) and repositionability/skin protection (ie, whether the device can be repositioned or the skin under the device can be protected) as new subscales.[10] The new subscales were added to address the risks associated with device-related pressure injury. Both the Braden Q and the Braden QD dichotomize scores into "at risk" and "no risk" categories. The Braden QD identifies patients with a score ≥ 13 as being at risk for hospital device-related pressure injury. The Braden Q score identifies hospitalized pediatric patients with a score of ≤ 16 as at risk for pressure injury. Due to the different subcategories and scoring, the numerical values of the scores cannot be compared; therefore, the risk category is a better predictor for the risk of the development of pressure ulcers.

QUICK LOOK

Current knowledge

Continuous pressure applied by a medical device against the skin can cause pressure injury. Pressure injury risk assessment tools have been developed to predict pressure injuries, but they have not been good predictors of NIV mask-related pressure injuries. The Braden QD scale was developed to predict the pressure injury risk of pediatric patients with medical devices.

What this paper contributes to our knowledge

The Braden Q scale did not identify subjects as being at risk for pressure injury when they later incurred injury. The Braden QD "at risk" score of ≥ 16 identified more NIV mask-related pressure injuries in pediatric subjects.

The purpose of this study was to retrospectively evaluate whether the Braden QD scoring tool was better able to correctly identify pediatric patients at risk for the development of medical device-related pressure injury during noninvasive ventilation (NIV) as compared to the Braden Q scale, which was previously used to identify risk for this population.

The Braden Q and Braden QD scores identify risk for pressure injury based on the combined total of their subscales. The total of the subscores were dichotomized by the author of the tools into "at risk" categories that were used in the study to evaluate patients who were identified with medical device-related pressure injury in the hospital setting to determine which scale was more predictive of the outcome. Subject scores were dichotomized based on this total to be at risk or not at risk for pressure injuries to determine whether the newer Braden QD scale was more accurate in predicting patients at risk.

We hypothesized that a Braden QD score in the "at risk" category of ≥ 13 will identify document pressure injury in more hospitalized pediatric subjects receiving NIV with a mask than will a Braden Q "at risk" score of ≤ 16.

Methods

Study Design

The study was approved by the University of California San Diego institutional review board. A waiver of con-

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sent was granted. This retrospective study examined all NIV mask-related pressure injuries from January 1, 2013, to December 31, 2018, from all care areas of the hospital. Subjects with NIV mask-related stage 1, 2, 3, or 4 deep tissue injury or with unstageable pressure injury were identified from the safety reporting system. Inclusion criteria were all subjects admitted during the time period with an acquired NIV mask-related pressure injury during hospitalization. Among these subjects, 18% had > 1 pressure injury from the device within the same admission. Subjects were included and data were collected from the first pressure injury during the hospitalization.

Study Variables

Braden Q and Braden QD Score

The Braden Q score with subscales was part of documentation in all charts for inpatients during the study period and was retrieved from the electronic health record by a single data collector for several time points: at time of admission, at 48 h prior to pressure injury, at 24 h before pressure injury, at the time of the injury, and at the time of resolution. To assess whether the new version of the scale was a more sensitive predictor, documentation of the previous scale was converted to a Braden QD score using the scoring directions for the scale. The Braden QD score was calculated by conversion of the Braden Q mobility, sensory perception, friction and sheer, nutrition, tissue perfusion/oxygenation subscale scores with the addition of number of devices and repositionability/skin protection, which was identified in the medical record and calculated according to the new scoring directions. The Braden Q subscale totals were converted to the Braden QD scale using a mathematical calculation so that all scores were converted uniformly. A single data collector collected the number of devices and repositionability/skin protections, which were added to the converted Braden QD subgroups score using a mathematical calculation for a final score. The McNemar test was used to compare classification outcome based on Braden Q and Braden QD scores at each time point.

Other data collected included age, sex at birth, race, history of dermatologic condition, diagnosis leading to NIV, type of respiratory mask associated with pressure injury, utilization of a pressure barrier, location of pressure injuries, and National Pressure Injury Advisory Panel classification (Table 1).

Table 1. Summary Demographics

Age at time of admission, y	11.3 (5.5)
Sex at birth	
Female	24 (53.3)
Male	21 (46.7)
Race	
Asian	2 (4.4)
Black or African-American	5 (11.1)
Hispanic or Latino	18 (40.0)
Native Hawaiian	1 (2.2)
Native American-Eskimo	1 (2.2)
Other	6 (13.3)
Other Pacific Islander	1 (2.2)
White or Caucasian	11 (24.4)
History of dermatologic condition	
No	42 (99.3)
Yes	3 (6.7)
Diagnosis leading to NIV	
Chronic respiratory failure	5 (11.1)
Obstructive sleep apnea	2 (4.4)
Pleural effusion	2 (4.4)
Pneumonia	17 (37.8)
Postoperative	9 (20.0)
Sepsis	2 (4.4)
Shock	1 (2.2)
Respiratory device associated with pressure injury	
Full face mask	26 (57.8)
Nasal mask	6 (13.3)
Nasal pillows	1 (2.2)
Nasal prongs	2 (4.4)
Total face mask	10 (22.2)
Skin barrier consistently 48 h prior to pressure injury	
No	6 (13.3)
Patient family refused	1 (2.2)
Yes	38 (84.4)
Location of respiratory device-related pressure injury	
Cheeks	6 (13.3)
Ear	1 (2.2)
Forehead	1 (2.2)
Nares	2 (4.4)
Nasal bridge	34 (75.6)
Septum	1 (2.2)
NPIAP (modified) classification for respiratory device-related pressure injury	
Full thickness loss	1 (2.2)
Nonblanchable erythema	22 (48.9)
Partial thickness skin loss	16 (35.6)
Suspected deep tissue injury-depth unknown	4 (8.9)
Unstageable	2 (4.4)

Data are presented as *n* (%). *N* = 45 subjects.
NPIAP = National Pressure Injury Advisory Panel.

Statistical Analysis

Continuous and categorical variables were reported as mean ± SD and count (percentage), respectively. Braden Q and Braden QD scores were electronically binarized and then dichotomized into 2 categories: no risk (Braden Q > 16 and Braden QD < 13) and at risk (Braden Q ≤ 16, and Braden QD ≥ 13) (Table 2). The McNemar test was used to compare the classification outcome based on binarized Braden Q and Braden QD scores on subjects at each time

Table 2. Conversion of Braden Q Subscale to Braden QD Subscale

Mobility		Sensory Perception		Friction and Sheer		Nutrition		Tissue Perfusion and Oxygenation	
Braden Q	Braden QD	Braden Q	Braden QD	Braden Q	Braden QD	Braden Q	Braden QD	Braden Q	Braden QD
4 (no limitations)	0 (no limitation)	4 (no impairment)	0 (no impairment)	4 (no apparent problem)	0 (no problem)	4 (excellent)	0 (adequate)	4 (excellent)	0 (adequate)
3 (slightly limited)	1 (limited)	3 (slightly limited)	1 (limited)	3 (potential problem)	1 (potential problem)	3 (adequate)	0 (adequate)	3 (adequate)	0 (adequate)
2 (very limited)	1 (limited)	2 (very limited)	2 (completely limited)	2 (problem)	2 (problem)	2 (inadequate)	1 (limited)	2 (compromised)	1 (potential problem)
1 (completely immobile)	2 (completely immobile)	1 (completely limited	2 (completely limited)	1 (significant problem)	2 (problem)	1 (very poor)	2 (poor)	1 (extremely compromised)	2 (compromised)

point collected. All statistical comparisons were 2–tailed, and the level of significance was set at $P = .05$. Statistical analyses were performed with R (R Foundation for Statistical Computing, Vienna, Austria).

Results

Forty-five unique subjects age 1 m – 23 y (mean ± SD 11.29 ± 5.53 y) with pressure injury were identified. In this sample, slightly more subjects were female (53.3%) (Table 2). McNemar test output can be seen in Table 3. At each time point, there was a statistical difference between Braden Q and Braden QD, with a Braden QD score ≥ 13 identifying risk for pressure injuries better than a Braden Q score < 16. Braden QD score ≥ 13 had a significant correlation with pressure injury at admission ($P < .001$), at 48 h prior to injury ($P < .001$), at 24 h prior to injury ($P < .001$), at the time of the injury ($P < .001$), and at the time of pressure injury resolution ($P < .001$). The Braden Q score of ≦ 16 identified 100% of subjects as being at no risk of pressure injury at admission, at identification of the pressure injury, and at 24 h prior to injury. The Braden Q score also identified 95.6% of subjects as being at no risk of pressure injury at 48 h prior to injury.

We also calculated the McNemar odds ratio for those values in disagreement at 48 h and at the time of pressure injury. At 48 h, the odds ratio was 14 (95% CI 3.53–121.28), and at the time of injury the odds ratio was 33 (95% CI 5.52–1,342.43).

We also reviewed 8 subjects who developed pressure injuries but were scored "not at risk" by the Braden QD. These 8 subjects were more likely to be female (3:1), and ethnicity was varied, including 1 Pacific Islander, 3 Native Hawaiians, and four Hispanic/Latino subjects aged 17–21 (mean 18 y).

Discussion

The new Braden QD score, which includes the number of devices and the use of barriers and repositionability of devices, classified more subjects with NIV mask-related pressure injuries as at risk at all time points collected, including at resolution of the pressure injury, compared to the Braden Q. While these subjects' pressure injuries may have been resolved, this may not decrease their risk of another injury. We found that 18% of subjects included in this study incurred > 1 pressure injury from their NIV mask during the same hospitalization (unpublished data). Findings from our retrospective study indicate that a Braden QD score ≥ 16 (ie, the "at risk" category) identified NIV mask-related pressure injuries in pediatric subjects.

In addition, we identified that for some Fitzpatrick skin types, particularly those with darker skin tone, the scale

Table 3. McNemar Test for Distribution

	Braden QD			
	No Risk	At Risk	*P*	Odds Ratio (95% CI)
Braden Q				
At admission				
No risk	7 (100)	38 (100)	< .001	Infinite (9.81–∞)
At risk	0 (0)	0 (0)		
At identification of skin change indicating injury				
No risk	8 (100)	37 (100)	< .001	Infinite (9.54–∞)
At risk	0 (0)	0 (0)		
48 h prior to skin change				
No risk	15 (88.2)	28 (100)	< .001	14.00 (3.53–121.28)
At risk	2 (11.8)	0 (0)		
24 h prior to skin change				
No risk	13 (100)	32 (100)	< .001	Infinite (8.18–∞)
At risk	0 (0)	0 (0)		
At time of pressure injury resolution				
No risk	11 (91.7)	33 (100)	< .001	33.00 (5.52–1,342.43)
At risk	1 (8.3)	0 (0)		

Data are presented as *n* (%). $P < .05$ shows statistical significance.

may not be as sensitive in identifying risk as it is for lighter skin tones. It has been reported that people with darker skin tones are more likely to develop higher stage pressure injuries than people with lighter skin tones.[12,13] The Fitzpatrick skin type may be a determinant of risk, and future studies should consider including this to analyze the effect.[14]

In a review of the literature in 2018, Alqahtani and AlAhmari[15] noted that interface selection, regular skin assessment and device rotation, limiting the pressure applied to the skin by the device, using a barrier between the skin and NIV mask, protecting the skin by keeping it dry and clean, and being aware of patient-related risk factors were all important in preventing maceration and minimizing friction. Additionally, hospital-acquired pressure injuries have garnered increased focus on prevention from institutional health care with the goal of improving outcomes, reducing severity, and meeting higher certification standards. These goals have clinicians searching the evidence for prevention measures.[16,17] Risk assessment has been described as the cornerstone of prevention.[18] The ability to quantify patient-related risk factors through a risk assessment tool may help identify patients at risk for NIV mask-related pressure injury, enabling more specific focus on observation and prevention for these patients.

Limitations to our study deserve comment. Due to the nature of a retrospective study, exposure and outcome assessment cannot be controlled and there was potential for measurement and sampling error. There is potential for non-differential bias due to the nature of the conversion of the Braden Q to Braden QD numerical value. This potential for error was minimized by agreement between 2 reviewers on the numerical conversion table. As data were collected only on subjects with known NIV mask-related pressure injuries, there is potential for an over- or underestimate of the association between the risk value and the outcome.

While the Braden QD and the Braden Q both are calculated values based on patient-specific risk factors, we found that the Braden QD scale was better able to correctly identify "at risk" subjects at all time points who developed NIV mask-related pressure injuries than the Braden Q scale. Future studies should include reviewing the specificity of this scale to determine its predictive risk value for NIV mask-related pressure injuries.

Conclusions

In summary, the findings from our retrospective study indicate that a Braden QD score ≥ 16, which is the "at risk" category, was more sensitive than the Braden Q scale in identifying pediatric subjects at risk for developing NIV mask-related pressure injuries. The use of the Braden QD tool may enable the prospective identification of patients at risk for pressure injury related to the use of a NIV mask.

REFERENCES

1. Agrawal K, Chauhan N. Pressure ulcers: back to the basics. Indian J Plast Surg 2012;45(2):244-254.
2. Gebhardt K. Pressure ulcer prevention. Part 1. Causes of pressure ulcers. Nurs Times 2002;98(11):41-44.
3. National Pressure Injury Advisory Panel. NPIAP pressure injury stages. Available at: https://npiap.com/page/PressureInjuryStages. *Accessed March 24, 2021.*

4. Han Y, Jin Y, Jin T, Lee SM, Lee JY. Impact of pressure injuries on patient outcomes in a Korean hospital: a case-control study. J Wound Ostomy Continence Nurs 2019;46(3):194-200.
5. Schindler CA, Mikhailov TA, Fischer K, Lukasiewicz G, Kuhn EM, Duncan L. Skin integrity in critically ill and injured children. Am J Crit Care 2007;16(6):568-574.
6. Razmus I, Bergquist-Beringer S. Pressure ulcer risk and prevention practices in pediatric patients: a secondary analysis of data from the National Database of Nursing Quality Indicators. Ostomy Wound Manage 2017;63(2):28-32.
7. Kottner J, Hauss A, Schluer AB, Dassen T. Validation and clinical impact of paediatric pressure ulcer risk assessment scales: a systematic review. Int J Nurs Stud 2013;50(6):807-818.
8. Tume LN, Siner S, Scott E, Lane S. The prognostic ability of early Braden Q Scores in critically ill children. Nurs Crit Care 2014;19(2):98-103.
9. Anthony D, Willock J, Baharestani M. A comparison of Braden Q, Garvin and Glamorgan risk assessment scales in paediatrics. J Tissue Viability 2010;19(3):98-105.
10. Curley MAQ, Hasbani NR, Quigley SM, Stellar JJ, Pasek TA, Shelley SS, et al. Predicting pressure injury risk in pediatric patients: the Braden QD scale. J Pediatr 2018;192:189-195.
11. Lauderbaugh DL, Bhattacharjee R, Proudfoot J, Ortega EV, Pratt LA, Popien TL, et al. Noninvasive ventilation device-related pressure injury in a children's hospital. Respir Care 2019;64 (12):1455-1460.
12. Oozageer Gunowa N, Hutchinson M, Brooke J, Jackson D. Pressure injuries in people with darker skin tones: a literature review. J Clin Nurs 2018;27(17-18):3266-3275.
13. Scanlon E, Stubbs N. Pressure ulcer risk assessment in patients with darkly pigmented skin. Prof Nurse 2004;19(6):339-341.
14. Roberts WE. Skin type classification systems old and new. Dermatol Clin 2009;27(4):529-533.
15. Alqahtani JS, AlAhmari MD. Evidence based synthesis for prevention of noninvasive ventilation related facial pressure ulcers. Saudi Med J 2018;39(5):443-452.
16. Visscher M, King A, Nie AM, Schaffer P, Taylor T, Pruitt D, et al. A quality-improvement collaborative project to reduce pressure ulcers in PICUs. Pediatrics 2013;131(6):e1950-e1960.
17. Centers for Medicaire and Medicaid Services, Health and Human Services. Medicaid program; payment adjustment for provider-preventable conditions including health care-acquired conditions. Final rule. Fed Regist 2011;76(108):32816-32838.
18. Fournier L, Kemp M, Farley K, McMyn R, Paulford N. A research-based risk assessment tool as the cornerstone of a pressure ulcer prevention program. J ET Nurs 1992;19(5):155-159.