Comparison of Pulse Oximetry versus Wang Score in Children Aged Three to Twenty-Four Months Admitted with Acute Bronchiolitis in Pak-Emirates Military Hospital, Rawalpindi

Aqsa Zafar, Muhammad Tariq Nadeem, Hira Ahmed, Tamoor Afzal*, Amina Pirzada, Maryam Waheed

Department of Paediatrics, Combined Military Hospital, Rawalpindi/National University of Medical Sciences (NUMS) Pakistan, *Department of Paediatirc Surgery, Pak-Emirates Military Hospital, Rawalpindi/National University of Medical Sciences (NUMS) Pakistan

ABSTRACT

Objective: To determine the diagnostic accuracy of the Wang score and pulse oximetry in detecting patients with severe acute Bronchiolitis.

Study Design: Cross-sectional validation study.

Place and Duration of Study: Department of Paediatrics, Pak-Emirates Military Hospital, Rawalpindi, Pakistan from Feb to Aug 2022.

Methodology: Seventy-five patients aged between three and twenty-four months, of both genders, with acute Bronchiolitis were included in the study. Those with cystic fibrosis, bronchial asthma, and congenital heart disease were excluded. Patients were assessed for the severity of Bronchiolitis based on a respiratory rate >40 or >35 breaths per minute in a less than one-year-old and a two-year-old, respectively, with a capillary pCO_2 of >41.8 mmHg. All patients underwent pulse oximetry, and an SpO_2 of <94% was considered indicative of severe disease, while a score of ≥4 on the Wang scoring was considered indicative of severe disease.

Results: Our study sample had a mean age of 11.88±5.78 months, the majority of whom were male, i.e., 41(54.7%). Wang score at a cut-off of level of ≥4 as a predictor for the presence of severe acute Bronchiolitis in children had a sensitivity of 68.18%, a specificity of 62.26% and a diagnostic accuracy of 64.00%, while SpO_2 measured using finger pulse oximetry had a sensitivity of 88.68%, a specificity of 73.91% and a superior diagnostic accuracy of 85.33% for the same.

Conclusion: The Wang score by itself is insufficient to determine whether severe acute Bronchiolitis is present, and requires employment in combination with other modalities such as pulse oximetry to be useful.

Keywords: Acute Bronchiolitis, Pulse Oximetry, Wang Score.

INTRODUCTION

Acute Bronchiolitis is a common viral infection (respiratory syncytial virus is the most common causative agent) of the lower respiratory airways, which frequently afflicts the paediatric population and causes mild to moderate symptoms that are usually self-limiting.[1] The disorder is reported to have an estimated incidence of 34 million cases per annum, globally, of whom 10% require hospitalization. Approximately 6% of children admitted with the disorder die from it.[2] Acute Bronchiolitis may be associated with the development of severe complications such as respiratory insufficiency, respiratory distress syndrome, the development of co-infections with other organisms (usually bacteria), and electrolyte imbalances due to persistent vomiting, along with treatment-related complications such as hospital-acquired infections, barotrauma due to the requirement for mechanical ventilation, and drug-induced cardiac arrhythmias.[1,3,4]

The diagnosis of acute Bronchiolitis is based on the patient's clinical picture, with laboratory testing and imaging having an ancillary role, while viral serology is usually not performed.[5] Monitoring of patients' condition is usually performed based on clinical picture as well, where patients are observed for the appearance of tachypnea, requirement for use of accessory muscles of respiration, development of subcostal/intercostal retractions, audible wheezing, flaring of nasal alae, and cyanosis.[6-8] The Wang score incorporates various clinical aspects of respiratory distress and has been previously used as a measure for the degree of respiratory distress in patients with acute Bronchiolitis, however, it lacks validation, especially in the Pakistani population, while pulse oximetry has also been routinely used to monitor patients with acute Bronchiolitis, with lower SpO_2 levels indicating the presence of severe disease, usually at levels lower than 94%.[9,10]

Correspondence: Dr Aqsa Zafar, Department of Paediatrics, Combined Military Hospital, Rawalpindi Pakistan

We conducted this study to determine the sensitivity, specificity, and diagnostic accuracy of the Wang score as well as pulse oximetry in detecting the presence of severe acute Bronchiolitis. Determining whether these modalities for surveillance are valid in this setting will decide whether they can be adopted as regular practice in cases of acute Bronchiolitis, which will help to predict the presence of severe disease in a timelier manner, and allow for the institution of appropriate management, which will result in a significant reduction in morbidity and mortality in these patients.

METHODOLOGY

The cross-sectional validation study was conducted between February and August 2022 at the Department of Paediatrics, Pak-Emirates Military Hospital, Rawalpindi, on 75 paediatric patients suffering from acute Bronchiolitis, after obtaining consent from their parents or guardians. Sample selection was carried out via non-probability, consecutive sampling. The WHO sample size calculator was used to calculate the sample size keeping an expected sensitivity of 56.3%, expected specificity of 81.25%, expected prevalence of 85.4%, a desired precision of 2 and a confidence level of 95%, which were the sensitivity and specificity of Wang score in the detection of severe respiratory disease and its prevalence, from Shinta-Devi et al.[11]

Inclusion Criteria: Patients aged between three and twenty-four months, of both genders, who had developed acute Bronchiolitis, which was defined as a viral respiratory prodrome followed by wheezing before the age of two years, were included.

Exclusion Criteria: Patients with chronic respiratory disorders such as bronchial asthma, α-1 antitrypsin deficiency, or cystic fibrosis, those with congenital heart disorders, or immune deficiency states were excluded.

Patient demographic data, including age and gender, were documented, and the diagnosis of acute Bronchiolitis was reconfirmed based on the patient's history and examination at presentation. Severe acute Bronchiolitis was defined, according to clinical/lab criteria, as a respiratory rate >40 or >35 breaths per minute in a child less than one year and a two-year-old, respectively, with a capillary pCO_2 of >41.8 mmHg at presentation.[12] All patients underwent pulse oximetry at this time, and an SpO_2 of <94% was considered indicative of severe disease.[11] Simultaneously, all patients underwent Wang scoring,

as per Table-I, and a score of ≥4 was considered indicative of severe disease.

Data was analyzed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows version 26, IBM Corp; Armonk, USA). Mean and SD were calculated for quantitative variables, specifically age, weight, duration of illness, respiratory rate on presentation, capillary pCO_2 level, Wang score, and SpO_2 at presentation. Qualitative variables, including gender, the presence of severe disease based on pCO2 levels, Wang score, and SpO_2, were recorded in terms of frequency and percentage. Qualitative data were compared between groups using the Chi-Square test/Fisher's Exact test, while quantitative variables were compared using the independent samples t-test. The 2 x 2 table was constructed to calculate the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of both the Wang score and pulse oximetry in detecting the presence of severe acute Bronchiolitis.

RESULTS

Our study sample was composed of 75 patients, of whom 41 (54.7%) were male. The mean age of the sample was 11.88 ± 5.78 months, with males presenting at a younger age than females with acute Bronchiolitis (*p*<0.001). The mean weight was 11.07±2.86 kg, with males having a lower mean weight (*p*<0.001). The mean time elapsed from the onset of symptoms to presentation to healthcare was 2.72±1.21 days. The mean capillary pCO_2 levels at presentation were 39.77±9.27 mmHg, while the mean Wang score and SpO_2 were 3.96±1.68 and 94.04±5.14%, respectively. Table-II shows the patient characteristics distributed according to gender. Table-III shows the constructed for both Wang score and SpO_2 to calculate the various test parameters. Wang score at a cut-off of≥4 as a predictor for the presence of severe acute Bronchiolitis in children had a sensitivity of 68.18%, a specificity of 62.26%, and a diagnostic accuracy of 64.00%. In comparison, SpO_2 had a sensitivity of 88.68%, a specificity of 73.91% and a superior diagnostic accuracy of 85.33% for the same at a cut-off of ≤94%, as displayed in Table-IV.

DISCUSSION

Acute Bronchiolitis is a clinical condition that can be associated with significant morbidity in paediatric patients, and may even be life-threatening. Key to effective management lies in determining when the patient's condition is severe, which may warrant the

Table-I: Wang Score

Score	Characteristics			
	Respiratory Rate	Wheezing	Retractions	General Condition
0	<30	None	None	Normal
1	31 - 45	Terminal expiratory, or only with stethoscope	Mild intercostal recessions	
2	46 - 60	Entire expiration, or audible without stethoscope during part of expiration	Mild tracheosternal recessions	
3	>60	Inspiration and expiration, without stethoscope	Severe recessions	Nasal flaring, lethargic, poor feeding

Table-II: Patient Characteristics According to Gender (n=75)

Variables	Male Patients (n=41)	Female Patients (n=34)
Gender	41(54.7%)	34 (45.3%)
Age (months)	8.93±4.34	15.44±5.30
Weight (kg)	9.61±2.14	12.82±2.65
Duration of Symptoms (days)	2.61±1.24	2.85±1.18
Respiratory Rate on Presentation (breaths/min)	40.93±16.50	44.88±17.70
Capillary pCO_2 (mmHg)	38.76±8.61	41.00±9.99
Severe Disease according to pCO_2	11(26.8%)	11(32.4%)
Wang Score	3.93±1.69	4.00±1.68
Severe Disease according to Wang Score	18(43.9%)	17(50.0%)
Oxygen Saturation SpO_2 (%)	94.73±4.66	93.21±5.62
Severe Disease according to Oxygen Saturation (SpO_2)	11(26.8%)	12(35.3%)

pCO_2: partial pressure of carbon dioxide, SpO_2: Oxygen Saturation

Table-III: Two by two-Contingency Table for Wang Score and Oxygen Saturation (n=75)

Parameters		Presence of Severe Acute Bronchiolitis According to Clinical/Lab Criteria		Total
		Yes	No	
Presence of Severe Acute Bronchiolitis according to Wang Score	Yes	True Positive: 15(20.0%)	False Positive: 20 (26.7%)	35
	No	False Negative: 7(9.3%)	True Negative: 33 (44.0%)	40
Total		22(29.3%)	53(70.7%)	75
Presence of Severe Acute Bronchiolitis according to SpO_2 (Oxygen saturation)	Yes	True Positive: 17 (22.6%)	False Positive: 6 (8.0%)	23
	No	False Negative: 5 (6.7%)	True Negative: 47 (62.7%)	52
Total		22 (29.3%)	53 (70.7%)	75

Table-IV: Diagnostic Parameters (n=75)

Test	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Diagnostic Accuracy
Wang Score	68.18%	62.26%	42.86%	82.50%	64.00%
Oxygen Saturation (SpO_2)	77.27%	88.68%	73.91%	90.38%	85.33%

use of assisted ventilation; respiratory scoring systems represent a potential tool to assess the severity of disease and may be helpful to assess paediatric patients in such situations.[13,14]

The majority of patients in our sample were male i.e., 54.7% (*p*<0.001). This slight male preponderance is in keeping with existing literature on the subject which reports a male-to-female ratio of 1.5 to 1 for the development of acute Bronchiolitis,[15] a fact that was also reported in recent studies such as that by Al-Shibli *et al*.[16] Moreover, males also tended to present at an earlier age with acute Bronchiolitis than females in our study, (*p*<0.001). Studies such as de Lusignan *et al*.

have previously reported that males tend to present at an earlier age with lower respiratory tract infections, such as acute Bronchiolitis, than females, which is in keeping with our findings.[17] This male predilection may be due to comparatively narrower airways in this population.[16]

The mean age of patients in our study sample was 11.88±5.78 months. Justice *et al*., and Erickson *et al*., report that the majority of cases of acute Bronchiolitis occur in patients less than 2 years of age,[1,6], while Al-Shibli *et al*., noted a median age of 6.6 months in their patients with acute Bronchiolitis which was in keeping with our determination that the

majority of cases occurred during the first year of life. It is pertinent to note that studies such as Wang *et al.*, have demonstrated a significant relationship between the occurrence of bronchial asthma in later life and a bout of acute Bronchiolitis in the first year of life.[18]

The mean weight of our patients was 11.07±2.86 kg, with males weighing less than females ($p<0.001$). Moshi *et al.*, noted that male children had a significantly higher incidence of having lower weights than females.[19] In contrast, literature has consistently noted that low- or under-weight paediatric patients in general and children born with low birth-weights in particular have an increased frequency of development of acute Bronchiolitis, which appears to be in keeping with our study results, and also have a higher chance of developing severe disease.[20,21]

Our study showed that the Wang score with a cut-off of ≥4 carried a sensitivity of 68.18%, a specificity of 62.26%, positive predictive value of 42.86%, negative predictive value of 82.50%, and a diagnostic accuracy of 64.00% for the prediction of the presence of severe acute Bronchiolitis. While our observations are mainly in agreement with existing studies, the slight variations in results may be attributable to inter-observer variability when assigning such clinical scores to individual patients.[22]

Pulse oximetry showing a SpO_2 <94% carried a sensitivity of 77.27%, a specificity of 88.68%, a positive predictive value of 73.91%, a negative predictive value of 90.38%, and a diagnostic accuracy of 85.33% in predicting the presence of severe acute Bronchiolitis in our study. While not previously researched in this aspect, previous studies and reviews have determined that SpO_2 of less than 94% is indicative of the presence of severe respiratory compromise requiring active, supportive measures, although this correlation determined in our study requires further validation.[23]

LIMITATIONS OF STUDY

The diagnosis of acute Bronchiolitis is based on clinical findings; milder cases may have been missed, and it is unclear how the Wang score and SpO2 may have correlated with such cases. Cases where the patient was hyperventilating due to anxiety or disease may have resulted in CO2, which may have affected how a patient's disease severity was classified. Additionally, interobserver variability in identifying and classifying clinical signs is a known phenomenon that may have resulted in some degree of confounding.

CONCLUSION

Acute Bronchiolitis is a commonly occurring disease that may require rapid assessment in the emergency department when deciding on the appropriate management, such as the employment of mechanical or assisted ventilation. The Wang score is a rapid measure of the severity of respiratory distress in such patients, but it lacks the diagnostic accuracy to be used in isolation. To improve its utility, combining it with parameters that are measurable at the bedside, such as pulse oximetry, may be more appropriate, which should be the focus of future research.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

AZ & MTN: Conception, study design, drafting the manuscript, approval of the final version to be published.

HA & TA: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

AP & MW: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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