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Original Research Article

A Study on Utility of Yale Observational Scale in Predicting Acute Bacterial Infections amongst Febrile Children in a Tertiary Care Hospital

C Lakshmi Prasanna[1], Shaik Karimulla[2], P Satya Prakash[3], P Nanaji Rao[4]

[1,2,3]Associate Professor, Department of Pediatrics, ACSR Government Medical College, Nellore
[4] Associate Professor, Department of Pediatrics, ACSR Government Medical College, Nellore

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Corresponding author: Dr. P Nanaji Rao
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Abstract:

Introduction: Fever is one of the most common presenting complaint and cause of hospital admission among children accounting for 15-30% of all hospital visits. It is important to differentiate between the bacterial and non-bacterial causes of fever. The use of the YALE observation scale (YOS) assists in the early recognition of acute bacterial infection more than other laboratory investigations as it is a simple, quick, easy-to-apply, and cost-effective bedside scale.

Objectives: To study the utility of the Yale observational scale in predicting Acute bacterial infection amongst febrile children.

Methodology: This was a hospital based Descriptive observational study, among 176 children admitted with febrile illness under the Department of Paediatrics, ACSR Government Medical College & Hospital, and Nellore. Children were clinically evaluated using YOS on admission. Laboratory investigations such as total leucocyte count, neutrophil count, CRP, blood culture, and any other relevant investigations were recorded. YOS score and lab parameters mentioned were statistically correlated with the presence or absence of bacteremia, need for antibiotics, and need for oxygen therapy and duration of hospital stay in febrile children.

Results: The mean YALE Observation Score among the subjects was 10.89 (± 3.17) ranging from 6 to 20. The mean YALE Observation Score was significantly higher among the children with a fever of 101.1 -103 F, Increased Duration of fever (> 6 days), > 15000/mm ^{3} WBC count, Positive CRP, > 10000/mm ^{3} Absolute Neutrophil Count, Positive culture evidence of bacteremia, increased duration of hospital stay (8 - 14 days) and need for antibiotics. The need for oxygen support was not significantly associated with the YALE Observation Score. The best cut-off of the YALE Observation Score for predicting Acute bacterial infection was 12.5 which has 65.9% sensitivity, 98.9% specificity, 98.12% positive predictive value, 76.88% negative predictive value and 83.53% diagnostic accuracy.

Conclusion: YALE observation scale can be used as a simple, quick, easy-to apply, and cost-effective bedside scale. Higher YOS score was significantly associated with adverse outcomes during the illness. Hence, the YALE observation scale assists in the early recognition of acute bacterial infection before the laboratory investigations.

Keywords: Yale observational scale, acute bacterial infection, febrile children, bacteremia, sepsis, accuracy.

Introduction

Fever is one of the most common presenting complaint and cause of hospital admission among children comprising nearly about 15% - 30% of all visits to the hospital. [1] Most of the infants presenting with the febrile illness have infections which are viral in origin, and only few are bacterial infections. [2] It is important to differentiate between the infections caused by bacterial and non-bacterial causes. [3] Untreated bacteraemia may lead to increased mortality; hence, early diagnosis and treatment leads to a decrease in mortality and sequelae of bacterial infections. [4] The clinical spectrum of the febrile illness extends from a benign course to a serious bacterial illness. Differentiating serious illness from benign fever is important, as it prevents serious consequences. [5] On the other hand; this exercise often requires expensive investigation, admission, and subsequently irrational usage of antibiotics. [6] Sepsis is considered one of the leading causes of mortality among children, under the age of 5 years. Sepsis is very hard to diagnose because of non-specific initial clinical presentation and there is a possibility for rapid deterioration. [7,8]

Complications of bacterial infections in children include deficits in motor and sensory components and mental deficits, and handicaps of the visual and auditory function. Renal tissue scarring can be caused by urinary tract infections including pyelonephritis, which can lead to chronic kidney disease. [4]

Blood culture and sensitivity is the gold standard to confirm the presence of bacteremia which usually takes 48 to 72 hours. No single laboratory investigation is specific to diagnose sepsis. Hence, the clinical tool is used to assess early identification of the presence of sepsis. [9,10]

Yale observation scale (YOS) is a bedside scale designed in 1982, by McCarthy et al, (<2 years, N= 165) which consists of six parameters (including the quality of cry, reaction to parents, state - variation, colour, the status of hydration, and response to social - overtures) in young children presenting with febrile illness, validated for grading the toxicity in the clinical state of febrile illness. [11]

The usage of biomarkers such as C-reactive protein and procalcitonin can be reliable, but it is costly and may not be applicable to the local population. [12] Usage of the YALE observation scale helps in the early identification of serious bacterial infections when compared with, other laboratory investigations as it is a simple, fast and easy to apply, and cost-effective bedside scale. [3]

Justification of the study/Need for the study: The actual challenge for Pediatrician is to identify infants with acute bacterial infections, with good reliability, without over testing or empirical treatment with antibiotics for infants with non-bacterial aetiologies for their febrile illness. There is currently no specific scale being used to predict acute bacterial infections on an OPD basis in the Indian population. There are very few studies on the validation of the Yale observation scale in India. This study aims to study the utility of the Yale observation scale for the prediction of acute bacterial infection among children with febrile illness.

Aim: To study the utility of the Yale observational scale in predicting Acute bacterial infection amongst febrile children.

Objectives: To assess the accuracy of the Yale observation scale in predicting the following among febrile children - Serious bacterial infections, Bacteraemia, presence of Sepsis and biomarkers of sepsis like CRP, duration of hospital stay, need for antibiotics and the need for oxygen support.

Methodology: This was a Hospital-based Descriptive observational study. Sample size was calculated and the minimum sample size required for the study was 175. 176 children over a period of 6 months were admitted with febrile illness under the Department of Pediatrics, ACSR Govt. Medical College, and Nellore.

Febrile Children (axillary temperature >39°C) aged 3-60 months, getting admitted through OPD and Casualty, whose parents were willing to give informed consent and those who were willing to get evaluated for blood tests were included in the study.

Children < 3 months of age and > 60 months, children with known chronic illnesses or with simple febrile seizures, children on immunosuppressive therapy or suffering from immunodeficiency states, chronic liver, respiratory, kidney, hemoglobinopathies, and congenital heart diseases were excluded from the study. Children with confirmed malaria, dengue or recognizable viral syndromes were also excluded from the study.

Children were clinically evaluated using YOS on admission. Lab investigations such as Total Leucocyte Count, Neutrophil Count, CRP, Blood Culture, and any other relevant investigations were recorded. YOS score and lab parameters mentioned were statistically correlated with the presence or absence of bacteremia, duration of hospital stay, the requirement for antibiotics, and the need for oxygen support in febrile children. Clinical details and investigation reports were documented in a study proforma.

Statistics: Numerical variables like Age, YOS scores, biomarkers of sepsis (CRP), etc, were represented in mean, SD, median, and mode. Categorical variables like gender, presence of sepsis, bacteremia, etc, were represented in percentages & frequencies. Data was collected and entered in an MS-excel sheet and analyzed using SPSS software version-16. P value was considered for statistical significance when less than 0.05.

Results

In this study, Children aged 3-60 months were included. 46 (26.14%) were in 11 - 20 months age followed by 39 (22.16%) who were 21 - 30 months age and least 10 (5.68%) who were 51 - 60 months age. In the study 96 (54.55%) were Males and 80 (45.45%) were Females. Among the Children studied, 147 (83.52%) had 100.4-101°F Temperature and 29 (16.48%) had 101.1-103 °F Temperature. And among them, 96 (54.55%) had 1-3 days of fever followed by 76 (43.18%) who had 4 - 6 days of fever, and least 4 (2.27%) who had > 6 days of fever.

66 (37.5%) children had WBC Count > 15000 mm ^{3} and 110 (62.5%) had < 15000 mm^3. 101 children had (57.4%) Positive CRP and 75 (42.8%) children had Negative CRP. 48 children (27.27%) had positive culture evidence of bacteremia and 128

(72.73%) had negative culture. Among the children, 94 (53.41%) required no antibiotics, followed by 76 (43.18%) who required antibiotics, and least 6 (3.41%) who required step up for antibiotics. 44 (25%) needed Oxygen support. Among the children, 123 (69.89%) had < 7 days of hospital stay followed by 53 (30.11%) who had 8 - 14 days of hospital stay.

Table 1: Distribution of YALE Observation Score in the study population (N=176)

YALE Observation Score	Frequency	Percent
6	2	1.14
7	13	7.39
8	42	23.86
9	15	8.52
10	37	21.02
12	12	6.82
13	2	1.14
14	21	11.93
15	16	9.09
16	10	5.68
17	1	0.57
18	4	2.27
20	1	0.57
Total	176	100.00
Mean – 10.89 SD- 3.17 Minimum 6.0 Maximum 20.0		

Table 2: YALE Observation score with temperature, Duration of fever, WBC Count, CRP

YALE Observation score	**Temperature**	**N**	**Mean**	**SD**	**Mean-diff.**	**p-value by 't' test**
	100.4-101 °F	147	10.23	2.93	4.010	0.001
	101.1-103 °F	29	14.24	2.06		
	Duration of fever	**N**	**Mean**	**SD**	**Mean-diff.**	**p-value by 't' test**
	1-3 days	96	10.01	2.75		0.001
	4-6 day	76	11.82	3.36		
	>6 days	04	14.50	1.29		
	WBC Count	**N**	**Mean**	**SD**	**Mean-diff.**	**p-value by 't' test**
	>15000	66	13.82	2.31	4.68	0.001
	<15000	110	9.14	2.16		
	CRP	**N**	**Mean**	**SD**	**Mean-diff.**	**p-value by 't' test**
	Positive	101	12.22	3.04	3.11	0.001
	Negative	75	9.11	2.37		

Table 3: YALE Observation score with Culture evidence of Bacteremia, Need for Antibiotic, Oxygen Support and Length of Hospital Stay

YALE Observation score	**Bacteremia**	**N**	**Mean**	**SD**	**Mean-diff.**	**p-value by 't' test**
	Positive	48	14.04	2.63	4.33	0.001
	Negative	128	9.71	2.48		
	Need for Antibiotics	**N**	**Mean**	**SD**	**Mean-diff.**	**p-value by 't' test**
	Not Needed	94	8.70	1.44		0.001
	Needed	76	13.29	2.78		
	Step Up Needed	06	14.83	1.17		
	Need for Oxygen Support	**N**	**Mean**	**SD**	**Mean-diff.**	**p-value by 't' test**
	Yes	44	11.82	3.10	1.23	0.079
	No	132	10.58	3.14		
	Hospital Stay	**N**	**Mean**	**SD**	**Mean-diff.**	**p-value by 't' test**
	< 7days	123	9.92	2.72	3.23	0.001
	8-14days	53	13.15	3.00		

Discussion: Fever is one of the most common presenting complaint and cause of hospital admission among children, which accounts for 15%- 30% of all hospital visits. [1] It is important to differentiate between bacterial causes from non-bacterial causes of fever (3). Use of the YALE observation scale assists in the early identification of serious bacterial infection when compared to

other laboratory investigations as it is a simple, fast, cheap, easy to apply, and cost effective bedside scale. [3]

Age of the children: In this study, we included Children aged 3-60 months. 46 (26.14%) belonged to the 11 - 20 months age followed by 39 (22.16%) who belonged to the 21 - 30 months age and least 10 (5.68%) who belonged to the 51 - 60 months age. Various studies have studied the prevalence and predictors of serious bacterial infection among various ages of children and observed that the pattern is different among various age groups, especially among children less than 3 months. [13,14,15]

Gender: In this study, among the children, 96 (54.55%) were Male and 80 (45.45%) were female children. We did not observe any significant relationship between the gender and Yale observational scale. P Mahajan et al did a stratified analysis with gender. [16] AL Hsiao et al, in their study, did not observe any significant relationship between the gender and Yale observational scale. [17]

Fever: In this study, among the children, the duration of fever was associated with significantly higher Yale observational scale scores. Amanda Pratt et al studied the Duration of fever and markers of serious bacterial infection among younger febrile children. They observed that the bacterial markers studied (AUC WBC, ANC, and CRP values) were more predictive of serious bacterial infection when the duration of fever was >12 hours. [18]

White Blood Cell Count: In this study, among the children, 66 (37.5%) had > 15000/mm3 WBC Count and 110 (62.5%) had < 15000/mm3 WBC Count. We observed a significantly higher YOS score among the children with higher WBC counts. Andreola Barbara et al, in their study, observed that the area under the ROC (AUC) obtained was 0.71 for WBC.

They concluded that the Procalcitonin and CRP are better diagnostic markers of severe bacterial infections among Children with febrile illness, compared to the total white blood cell count and absolute neutrophil count. [19]

CRP: In this study, among the children, 101 (57.4%) had positive CRP and 75 (42.8%) had negative CRP. We observed a significantly higher YOS score among the children with positive CRP. Various studies have observed a significant relationship between the higher CRP and adverse outcomes and higher Yale observational scale scores. [20-23] C-reactive protein and procalcitonin have been studied as predictors for severe bacterial infection among febrile children in various studies and concluded them as good predictors. [19,24,25]

Absolute Neutrophil Count: In this study, among the children, 65 (36.93%) had >10000/mm3 Absolute Neutrophil Count and 111 (63.07%) had <10000/mm3 Absolute Neutrophil Count. We observed a significantly higher YOS score among the children with higher Absolute Neutrophil Count. Sukanya De et al, in their study, observed that the total white blood cell count and absolute neutrophil count alone cannot be used as a predictor for severe bacterial infection among febrile children. [26]

Marjaneh Zarkesh et al, concluded that the IL-6 and C-Reactive-Protein are better diagnostic markers of severe bacterial infections in febrile children, compared to the total white blood cell count and absolute neutrophil count. [27] Hayri Levent Yilmaz et al, observed that the Yale Observation Scale scores, band neutrophil ratio, absolute neutrophil count, percentages of neutrophil and bands, and absolute band count were found to be significant predictors of bacteremia among febrile children. [28]

Bacterial Culture: Sepsis is one of the leading causes of mortality among children, under the age of 5 years. [7,8] Blood culture & sensitivity is the gold standard to confirm the presence of bacteremia which usually take 48 hrs-72 hrs. No single Laboratory investigation is specific to diagnose sepsis. Hence, the clinical tool is used to assess early identification of the presence of sepsis. [9,10] In this study, 48 (27.27%) had positive culture evidence of bacteremia and 128 (72.73%) had negative Culture.

We observed a significantly higher YOS score among the children with positive culture. A study conducted by Akash Bang and Pushpa Chaturvedi observed in their study that 28.16% of subjects had bacteremia. [3]

Comparison of YALE Observation Score with the parameters: In this study, YALE Observation Score is the Significantly higher among the children with a fever of 101.1-103 F, Increased Duration of fever (> 6 days), > 15000/mm3WBC count, Positive CRP, > 10000/mm³ Absolute Neutrophil Count, Positive Culture evidence of bacteremia, Increased duration of hospital stay (8 - 14 days) and need for antibiotics. In this study, the need for Oxygen support was not significantly associated with the YALE Observation Score. This may be possible due to a spurious association, between identifying the complications earlier and treating them adequately. In this study, the area under the curve for YALE Observation Score in predicting Acute bacterial infection is 0.922 (0.884 - 0.961). In this study, the best cut-off of the YALE Observation Score for predicting Acute bacterial infection was 12.5 which has 65.9% sensitivity, 98.9% specificity, 98.12% positive predictive

value, 76.88% negative predictive value and 83.53% diagnostic accuracy.

A study conducted by Akash Bang and Pushpa Chaturvedi showed a YOS score of more than 10 as the best cut-off for the prediction of bacteremia. The area under the ROC curve was 0.91. The sensitivity of the YOS score was 87.9% and the specificity was 83.8%. They concluded that the YALE Observation Score is a simple, fast, easy, and cost-effective test for the prediction of bacteremia in children, presenting with fever, aged 3months-3 years as the child has higher sensitivity value and good reproducibility. [3]

In this study, the need for oxygen support was not significantly associated with the YALE Observation Score. Similar to our study results, Shagun Walia et al, observed the specificity, sensitivity, and Positive and negative predictive values for a Yale observation scale and yielded a good predictive value for the need for mechanical ventilation, the requirement for scaling the grade of antibiotics, and mortality. [30]

Yu Masuda et al. conducted the study in Japanese primary care settings and observed that the specificity, sensitivity, and positive and negative predictive values for a Yale observation scale score greater than 10 to identify the severe pediatric diseases.31 Prerana Kansakar et al, observed that the specificity, sensitivity, and positive and negative predictive values for a Yale observation scale score greater than 10 to identify the serious bacterial infection were 88.05%, 45.45%, 65.21%, and 76.62%, respectively. [5]

P. Sudhakar and P. Ajitha, in their study observed a cut-off value of 14.5 yielded a sensitivity and specificity of 97% and 79.6% respectively. [29] Similar to our study results, Motia Javed et al, observed that the specificity, sensitivity, and positive and negative predictive Values for a Yale observation scale score to identify serious bacterial infections were 90.63%, 79.45%, 65.91%, and 95.08%, respectively. [32] To this study, we did not do a cost-effective analysis, but Neh D. Molyneaux et al, observed that usage of Rochester Criteria and Yale Observation Scale Score reduced the health care costs by reducing the laboratory testing for cerebrospinal fluid, administration of empirical antibiotics, and prolonged hospitalization. [33] Contrary results were observed in the study by Stephen J. Teach et al who concluded that the difference in the Yale Observation Scale is not clinically useful. They observed that the specificity, sensitivity, and positive and negative predictive values for a Yale observation scale score greater than 10 to identify the severe disease were 5.2%, 96.7%, 4.5%, and 97.1%, respectively. [34]

Hence, we conclude the YALE observation scale can be used as a simple, fast, easy, and cost-effective bedside scale. Higher YOS Significantly associated with adverse outcomes during the illness. Hence, the YALE observation scale assists in the early identification of acute bacterial infection before the laboratory investigations.

Limitations: The role of the confounding factors influencing the severity of infection and YOS cannot be ruled out in this study. Nevertheless, the factors such as age and gender were not significantly associated with the YOS score. The sample size was calculated based on the sensitivity of the YOS score in the prediction of Severe Bacterial Infection among febrile children; hence the inferences on the other associated factors were not studied adequately. This is a hospital-based study in a tertiary care setting; hence the study results cannot be generalized to the children attending other settings such as primary and secondary care. The study did not have a long term follow-up to study the associated complications and long term sequelae due to the severe bacterial infection. Markers such as procalcitonin and IL-6 were not included in the study.

Strengths: The possibility of inter-observer variation is reduced using the scale by only the principal investigator throughout the study period. The study was conducted in a tertiary care hospital and referral to higher centers will be minimal and hence the attrition rate will be minimal.

Recommendations: YALE observation scale can be used as a simple, fast, easy, and cost-effective bedside scale. Higher YOS significantly associated with adverse outcomes during the illness. Hence, the YALE- observation scale can help in the early identification of acute bacterial infection before the laboratory investigations. Further studies with slightly increased sample sizes done also in primary and secondary care settings will identify the true applicability of the YALE observation scale. Future studies can focus on the combination of other parameters, (clinical or biochemical) with the YALE observation scale to increase the accuracy.

Conclusion:

The mean YALE Observation Score is significantly higher among the children with a fever of 101.1 - 103°F, increased duration of fever (>6 days), > 15000/mm^3 WBC count, positive CRP, >10000/mm^3 absolute neutrophil count, positive culture evidence of bacteremia, increased duration of hospital stay (8 - 14 days) and need for antibiotics. YALE Observation Score has good specificity, and positive predictive values indicating higher Scores have more prediction of acute bacterial infection among children presenting with febrile illness. We conclude YALE observation scale can be used as a simple, rapid, easy, and cost-effective bedside scale. Higher YOS

Significantly associated with adverse outcomes during the illness. Hence, the YALE observation scale can help in the early identification of acute bacterial infection before the laboratory investigations.

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