Original Article

Yale Observation Scale for Prediction of Bacteremia in Febrile Children

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ABSTRACT

Objective. To assess the accuracy and reliability of yale observation scale (YOS) predicting bacteremia.

Methods. 219 consecutive febrile inpatients aged 3-36 months were the subjects. Before giving antipyretics, rectal temperature was recorded. YOS scores were assessed by 2 independent blinded residents. History, clinical examination and investigations followed. Blood cultures were taken in all children before antibiotics. Point estimates and 95% confidence intervals were calculated for sensitivity, specificity, positive & negative predictive values and likelihood ratios for use of YOS as a diagnostic test in prediction of bacteremia. The best cut off value for a positive YOS test was established by calculating these statistical values separately for a cut off YOS score of 8, 10 and 12 and plotting ROC curve. Reliability of YOS was assessed by the inter-observer agreement through kappa statistics.

Results. Study population (n=219) had 59.36% males and a mean age of 15.24 months. 28.16% subjects had bacteremia. Mean YOS scores were significantly higher in bacteremic children (14.9 *vs* 8.78 in non-bacteremic, p=0.00001) Sensitivity, specificity, PPV, NPV, LR+ and LR- of YOS score >10 to predict bacteremia were 87.93%, 83.78%, 68.00%, 94.66%, 5.42 and 0.14 respectively. Those of YOS score >8 were 96.55%, 65.54%, 52.34%, 97.98%, 2.80 and 0.05 respectively and of a YOS score >12 were 48.28%, 91.22%, 68.29%, 81.82%, 5.5 and 0.5 respectively. ROC curve showed YOS score >10 to be the best cut off for prediction of bacteremia. Area under ROC curve was 0.9001. The chance corrected inter-observer agreement (kappa) was 0.7919.

Conclusion. YOS is a simple, easy to administer, cost-effective and useful test to predict bacteremia in a febrile child aged 3-36 months due to its high sensitivity and reproducibility. **[Indian J Pediatr 2009; 76 (6) : 599-604]** *E-mail: drakashbang@gmail. com, dr_akashbang@rediffmail.com*

Key words : *Yale observation scale; Fever; Bacteremia*

Fever is one of the commonest complaints in children for which parents seek help.[1] In young febrile children, differentiation between bacterial and non-bacterial causes of fever is necessary owing to a high incidence of viral infections and the fact that fever may also be due to bacteremia even in absence of localizing signs. Untreated bacteremia can cause serious complications including death, and hence an early diagnosis of bacteremia in a febrile child is crucial in reducing childhood mortality. On the other hand, rationalization of antimicrobial therapy is necessary to avoid the increasing emergence of resistant bacterial strains. Obtaining a blood culture in resource-restrained settings, particularly in rural hospitals, is difficult. Detailed physical examination needs more time, expertise and may not yield classical signs especially in young children.

Yale Observation Scale (YOS) **(Annexure 1)**, is an observational scale consisting of 6 observational items originally characterized and clubbed by McCarthy *et al*[2] in 1982, and validated in young febrile children (< 24 months, N= 165) to detect a serious illness. It is simple, quick, easy to apply and cost-effective, as it is purely observational and does not contain investigational items.

We aimed to assess the accuracy and reliability of YOS in febrile children aged 3-36 months for predicting bacteremia.

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ANNEXURE 1. Yale Observation Scale

Observation item	Normal (Score=1)	Moderate Impairment (Score=3)	Severe Impairment (Score=5)
1. Quality of cry	Strong with normal tone OR Content and not crying	Whimpering OR Sobbing	Weak OR Moaning OR High pitched
2. Reaction to parent stimulation	Cries briefly then stops OR Content and not crying	Cries off and on	Continual cry OR Hardly responds
3. State variation	If awake → Stays awake OR If asleep and stimulated → wakes up quickly	Eyes close briefly awakes up with prolonged stimulation	Awake OR Falls to sleep OR Does not wake up
4. Color	Pink	Pale extremities OR Acrocyanosis	Pale OR Cyanotic OR Mottled OR Ashen
5. Hydration	Skin normal, eyes normal AND Mucous membranes moist	Skin, eyes- normal AND Mouth slightly dry	Skin doughy/tented AND Dry mucous membranes AND/OR Sunken eyes
6. Response (talk, smile) to social overtures	Smiles OR Alerts (≤2 mo)	Brief smile OR Alerts briefly (≤2 mo)	No smile, Face anxious/dull/ expressionless OR No alerting (≤2 mo)

MATERIALS AND METHODS

Mahatma Gandhi Institute of Medical Sciences (MGIMS) is a rural school located in a small town in Maharashtra, India. The department of Pediatrics admits every year about 3000 children aged less than 12 years, of which 40 - 50% have a history of fever. Microbiology department of the hospital offers round the clock services for culturing blood and body fluids.

We prospectively enrolled all children aged 3 to 36 months who were admitted to the pediatric ward of MGIMS and had a documented fever in the hospital – defined as rectal temperature > 38°C.[3,4,5] We excluded children if they developed fever more than 8 hours after they were admitted to the hospital or were known to have an immunodeficiency state.

A consecutive sampling method was used to recruit all consecutively admitted patients fulfilling the inclusion criteria. In the present study, we assumed the sensitivity and specificity of the index test (YOS) to be 80% each, based on the published literature. We focused our sample size calculation on the bacteremic (disease positive) patients and calculated that to achieve confidence interval (C.I.) of ±10% estimates of sensitivity and specificity, we needed to recruit about 60 bacteremic patients.

The rectal temperatures were measured at the first peak of fever, before administering any antipyretics, with a clinical mercury-in-glass rectal thermometer. The thermometer was kept inserted for 3 minutes[6,7] approximately 3 cm deep into the rectum.[8,9] Fever was defined as a rectal temperature of >38°C.[3,4,5] This was followed by assessment of YOS scores with the child seated on the parent's lap or if necessary, on a warmed sheet in an undisturbed supine position on an examination table. The items which require minimal or no observer interaction or intervention (*e.g.*, color, state of wakefulness) were scored first, followed by other items requiring interaction. The scoring was independently done by 2 different residents blinded to each other's scores. If they disagreed, the consultant's score was taken as the final YOS score. This was followed by relevant history including demographic details and clinical examination. We collected 5 ml of venous blood from all children; it was immediately incubated and later cultured in bile and tryptic soy broths. Blood cultures were withdrawn in the entire study population irrespective of the results of the YOS scores and before administering the antibiotics, with all the required aseptic precautions. Blood cultures, reported by the blinded microbiologists, were considered "reference standard" for a diagnosis of bacteremia which was defined as the growth of a non-contaminant pathogen as reported by the microbiologist.

Mean (SD) YOS scores were calculated for children with and without bacteremia. Point estimates and 95% confidence intervals were calculated for the sensitivity, specificity, positive and negative predictive values (PPV and NPV) and positive and negative likelihood ratios (LR+ and LR-) for the use of YOS as a diagnostic test for prediction of bacteremia. We used receiver operating characteristic curves (ROC) to obtain a cut off point that maximizes the diagnostic accuracy of the YOS score. The ROC scores were calculated by plotting true positives and false positives. The best cut off value for a positive YOS test was tried to be established by calculating these statistical values separately for a cut off YOS score of 8, 10 and 12 and then plotting the ROC curve for YOS. Reliability (reproducibility) of YOS was

tested by calculating the inter-observer agreement between the two blinded and independent observers through kappa statistics. A kappa value of 0 indicates that the observed agreement is completely due to chance, whereas a value of 1 indicates a perfect agreement. Other values were graded according to the following guidelines:[10] kappa<0.2: poor agreement, 0.21–0.4: fair agreement, 0.41– 0.6: moderate agreement, 0.61–0.8 good agreement, and 0.81–1.0: very good agreement.

RESULTS

The study population (n=219) had a mean age of 15.24 (SD = 11.68) months; 60% study children were males. Young infants aged 3 to 6 months constituted the largest age group, (71 of 219 = 32.42%) and had the maximum mean (SD) YOS score of 11.94 (5.04). The mean (SD) YOS score of the overall study population was 10.9 (5.08) (Table 1). Thirteen records were excluded from the analysis because the blood cultures were contaminated. Amongst the remaining 206, the prevalence of bacteremia was 28%. The mean YOS score in the children with bacteremia was 14.9 (95% C.I. 13.70, 16.09). This was significantly higher than that in the non-bacteremic children. (Mean 8.78; 95% C.I. 8.27, 9.29; p=0.00001). For prediction of bacteremia, sensitivity, specificity, PPV, NPV, LR+ and LR- of different cut off values of YOS *viz.* 8, 10 and 12 are summarized in table 2.

Receiver operating characteristic curves (ROC) obtained by plotting sensitivity on Y-axis against (1-specificity) on X-axis for each of the cut off values of YOS scores showed that the point on the ROC curve nearest to top left corner (where sensitivity and specificity both are 1 or 100%) corresponded to a YOS score of 10 (Fig. 1). The area under ROC curve was 0.9001. The chance corrected inter-observer agreement (kappa) was 0.79.

Table 1. Age Distribution of the Study Population and their Mean YOS Scores

Sr No	Age Group (in months)	Total cases		YOS score	
		Number	Percentage	Mean	SD
1	3-6	71	32.42%	11.94	5.04
2	7-12	53	24.20%	9.96	3.47
3	13-18	25	11.42%	10.24	4.29
4	19-24	20	9.13%	10.80	6.33
5	25-30	17	7.76%	11.65	5.48
6	31-36	33	15.07%	10.55	6.58
	Total	219	100%	10.9	5.08

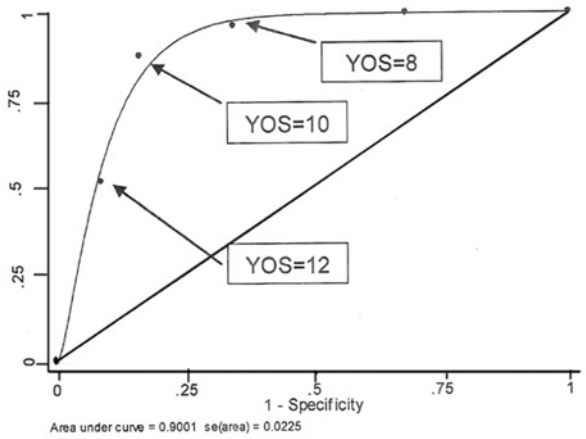

Fig. 1. ROC curve for YOS as a diagnostic test to predict bacteremia
Note: Area under curve = 0.9001; SE (area) = 0.0225

DISCUSSION

Young febrile children are known to have bacteremia which can lead to serious consequences. Earlier studies[11,12,13,14] have reported a bacteremia prevalence ranging from 1.6% to 12.9%. The higher bacteremia

Table 2. Diagnostic Value of Various YOS Scores for Prediction of Bacteremia

	YOS score cut-off used to predict bacteremia		
	>8 taken as positive test	>10 taken as positive test	>12 taken as positive test
True Positives	56	51	28
False Positives	51	24	13
True Negatives	97	124	135
False Negatives	2	7	30
Total	206	206	206
Sensitivity	96.55(79.3,98.6)	87.93(71.0,92.8)	48.28(26.9,56.0)
Specificity	65.54(55.2,71.6)	83.78(73.0,87.3)	91.22(67.3,89.8)
PPV	52.34(42.5,62.1)	68.0(56.2,78.3)	68.29(51.9,81.9)
NPV	97.98(92.9,99.8)	94.66(89.3, 97.8)	81.82(75.1,87.4)
LR +	2.80(2.23,3.52)	5.42(3.71,7.92)	5.5(3.0,9.8)
LR –	0.05(0.01,0.21)	0.14(0.07,0.29)	0.57(0.44,0.73)

Note: Figures in (parentheses) indicate 95% confidence intervals. PPV= Positive predictive value, NPV= Negative predictive value, LR+ = Positive likelihood ratio, LR- = Negative likelihood ratio

prevalence in the present study was probably because we sought bacteremia as a whole as the outcome variable without restricting to occult bacteremia unlike some earlier studies. Secondly, the subjects being inpatients, were expected to have more prevalence than the febrile outpatients recruited in most of these studies.

The present study shows that YOS is a reasonably accurate test to predict bacteremia. The high negative predictive value associated with YOS indicates that these scores are very good at ruling out bacteremia. However, a positive YOS score must be interpreted with caution. It is well documented that a host of external influences can worsen the overall clinical appearance of a febrile child, and thereby, the YOS scores.[15] Further, the parameters assessed are geared towards symptoms/signs of basic vital functions and organ dysfunction due to any cause. Hence, a child with a positive YOS score must be investigated further. Thus, YOS can be a good diagnostic test especially useful for triage in a busy emergency ward.

Sensitivity and specificity issues: As the cut off value for a positive YOS score was increased from 8 to 12; sensitivity, NPV and LR- kept on decreasing which meant missing increasingly more number of bacteremic children. On the other hand, specificity, PPV and LR + all kept on increasing. However, for a good diagnostic test, both sensitivity as well as specificity have to be reasonably good. Any one of these cannot be compromised at the cost of the other. Thus the best cut off value for positive test is the one for which both these values are high. As seen in table 2, the highest and best trade-off in the values of sensitivity and specificity was obtained at the cut off value of 10.

This was confirmed by plotting the ROC curve. (Fig. 1) The top left corner in the ROC curve is the point where both sensitivity and specificity are 1 or 100% – a most ideal situation but quite rare in reality! In our study, the point on the ROC curve nearest to the top left corner corresponded to a YOS score of 10. This confirmed that a YOS score of 10 is the best cut off for using YOS as a diagnostic test in the prediction of bacteremia. Also, for any diagnostic test, higher the area under the ROC curve, the better the test is. In the present study, the area under ROC curve was 0.9001 *i.e.*, very high and nearing the ideal value of 1.0, hence signifying that YOS is overall a good test to predict bacteremia in febrile inpatients aged 3 – 36 months.

In clinical practice, a kappa value (chance corrected inter-observer agreement) of >0.6 is taken as good agreement and that of >0.8 as very good agreement.[10] Hence YOS, with its kappa value of 0.79 comes across as a highly reproducible clinical observation scale with a very good inter-observer agreement.

McCarthy *et al* (1982) published for the first time- a predictive model scale[2] – today known as YOS – using only those six items out of an earlier list of twenty,[16] that turned out to be significant and independent predictors of serious illnesses. Since then, YOS has been quite an under-estimated and under-researched tool. A summary of previous researches on YOS is presented in table 3. Most of these studies aimed to study the prevalence of "occult" bacteremia in a febrile child who was otherwise non-toxic, non-ill and was treated as outpatient (OPD) and hence had a lower prevalence of bacteremia (2.9 to 12.3%). A lower sensitivity and PPV concluded in most of these studies may be a result of this low prevalence due to exclusion of serious patients and false dilution with OPD patients. However, in all the studies, NPV of the YOS score >10 has been

Table 3. Comparison of Studies on Diagnostic Use of YOS

Authors (Year)	Sample size (N)	Study population	Outcome assessed	Sens (%)	Spec (%)	PPV (%)	NPV (%)	Remarks
McCarthy *et al*[2] (1982)	165	OPD+Emergency room, ≤24mths, ≥38.3°C	Serious illness n=26 (15.8%)	77	88	56	97.3	Kappa w = 0.47 to 0.73
Baker MD *et al*[19] (1990)	126	Emergency room, 29-56d, ≥38.2°C	Bacterial disease (9.5%)	33	73	11	91	Age group < 2 mths Concl: not useful
Baker RC *et al*[18] (1989)	154	OPD+Emergency room 3-24mths, ≥39.4°C	Bacteremia (Occult+with focus) n=19 (12.3%)	68	77	30		Sampling by convenience
Teach *et al*[17] (1995)	6611	OPD, 90d-36mths, ≥39°C	Occult bacteremia n=192 (2.9%)	5.2	96.7	4.5	97.1	Non-toxic non-ill patients
Jamuna *et al*[12] (2000)	100	OPD+Casualty, 3-36mths, ≥99°F, Fever<4d	Occult bacteremia n=4 (4%)	100	41.6	6.6	100	Small sample
Present study	219	Inpatients, 3-36months, ≥38°C	Bacteremia (Occult + Overt) (28.16%)	87.9	83.8	68.0	94.7	Consecutive sampling

Key: OPD= Out Patient Department, Sens = sensitivity, Spec = specificity, PPV = Positive predictive value, NPV = Negative predictive value

outstandingly better than its PPV. Baker RC *et al*[18] (1989) were closest to the present study in their patient population and the outcome measured. However, they too excluded patients with overt meningitis and septic shock; included OPD patients; and did not recruit patients in a consecutive sampling manner, instead opting for a "convenience sampling" which probably introduced a selection bias.

From past studies, two clear observations can be made. Firstly, YOS is not useful in predicting a bacterial disease in a young infant below 8 weeks of age.[19] The poor results are attributed to a low prevalence in the selected population and the inherent neurological immaturity of young infants. Secondly, YOS performs poorly when the estimated prevalence of bacteremia (*i.e.*, pre-test probability of bacteremia) is low *e.g.*, non-toxic non-ill OPD patients and thus is not a good screening test to be applied to general non-ill patients where, anyway bacteremia is less likely. Conversely, when bacteremia is likely, YOS can be used to rule out bacteremia, thus decreasing the need of blood cultures.

The present study aims to validate the use of YOS in such settings and gives a fair representation of the patient population presenting to a rural based hospital and deals with bacteremia as a whole, without restricting to occult bacteremia. This is a wider, more realistic and more practical approach to the outcome measurement. This also ensured that there was no spectrum bias and no recall bias and thus, all inpatients with documented fever were recruited. OPD patients were not included to avoid the dilution of prevalence of bacteremia with the non-serious / non-toxic OPD patients. A consecutive sampling avoided any selection bias. A procedural uniformity in recording the rectal temperatures prior to antipyretics, in applying YOS and in collection of the blood samples and use of regularly calibrated reliable thermometers minimized procedural and instrumental sources of variations. All the subjects were subjected to blood cultures irrespective of the YOS scores, thus avoiding a verification bias. Other strengths of the study included an independent YOS scoring done by two blinded residents for agreement analysis; and total blinding of the microbiologists (who tested and analyzed blood cultures) to the YOS score and the clinical assessment.

Though the earlier studies have established uselessness of YOS in OPD patients,[17] the exclusion of OPD patients remains a limitation of this study. However at this point, it may be noted that to avoid "verification bias", the whole study population must be subjected to the reference standard test. Hence conducting such a study in OPD setting would be logistically difficult as it would mean subjecting every febrile OPD child to blood cultures. Also, hospital-based studies have their own limitations as admitted patients are a filtered population with a relatively higher severity of illness and a likelihood of bacteremia. Thus YOS needs to be tested in wider and community based studies. The use of blood cultures as reference standard also has its own inherent limitations.

CONCLUSION

Yale Observation Scale (YOS) is a simple, easy to administer, cost-effective and useful test to judge the overall clinical appearance of a young febrile child where a physical examination may not yield any specific information. The best cut off is a YOS score of >10. This is a very sensitive test for prediction of bacteremia and a normal YOS score (≤10) rules out bacteremia in a febrile child with reasonable accuracy. However, an elevated YOS score is not very specific for bacteremia as other internal (non-bacterial) and external influences can result in a high score. It is a highly reproducible clinical observation scale with a very good inter-observer agreement. The simplicity of the scale, its sole reliance on clinical observations *vis-à-vis* investigations, zero cost involved and a very good reproducibility make it a very good triage tool even in the hands of peripheral health care workers, junior residents, nurses etc. However, further studies in community settings are recommended to strengthen this extrapolation. Normal YOS scores (≤10) can be of extreme help in a busy hospital with a need for triage. A febrile child with an elevated YOS score (>10), however, needs further work up and referral to a center with investigational facilities to reduce further mortality and morbidity.

Contributions: AB prepared the initial protocol; reviewed literature; planned and conducted the study; recorded and analysed the results; and prepared manuscript-PC conceptualized and guided the study and reviewed manuscript.

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