Original Article

The use of vital signs as predictors for serious bacterial infections in children with acute febrile illness in a pediatric emergency setting in Sudan

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ABSTRACT

Distinguishing children with serious infections from those with milder, self-limiting febrile illnesses remains a daily challenge in primary care and hospital emergency department. Measurement of vital signs is recommended as part of this assessment. To determine whether vital signs can predict children with serious bacterial infections, we studied the data of children aged 1 month to < 16 years presented who with acute febrile illness to a Pediatric emergency department in Sudan. Sample size was 150 patients. The severity of infection was classified as serious or not serious bacterial infection. Vital signs and oxygen saturation were recorded and compared to the final outcome of these children. Data analyzed bivariably and multivariably using regression analysis. Ten percent of patients were classified as having serious bacterial infection. Tachycardia and tachypnea were the most sensitive and specific in predicting serious bacterial infections with (80%, 86.6 % sensitivity) and (97.4%, 83.7% specificity), respectively. High temperature, severe hypoxemia and hypotension were the least sensitive but highly specific signs of serious bacterial infections. As a conclusion, vital signs can be used to differentiate children with serious bacterial infections from those with non-serious bacterial infections in pediatric emergency departments and has comparable sensitivity to more complicated triage systems.

Keywords:

Child; Sensitivity and specificity; serious bacterial infections; vital signs.

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INTRODUCTION

In spite of the great progress in the prevention of childhood infections, particularly through immunization, infection remains a leading cause of illness and death among children in the developing countries [1]. Even in the UK, a recent confidential enquiry about child deaths found that infection was the single largest cause of death in children [2]. Although early recognition of sepsis is associated with better treatment outcomes [3,4], this report and others have highlighted the difficulty often faced by clinicians in recognizing serious illness in children, partly because many of the early clinical features of serious bacterial infection (SBI) also occur in milder and self-limiting febrile illnesses [2,5,6].

Serious infections in children are usually defined as sepsis, meningitis, pneumonia, pyelonephritis, bacterial gastroenteritis, osteomyelitis, and cellulitis [7,8]. Infectious and noninfectious diseases can cause fever and the vast majority of young children with fever have an infectious etiology. Although caretakers may sometimes attribute fever to teething, fever >38.5ºC is unlikely to be caused by teething and the source of fever may be a recognizable bacterial or viral illness [9]. In a study of a large cohort of children 3 to 36 months of age presenting to a primary care provider with a febrile illness, a readily identifiable bacterial illness was diagnosed at the initial encounter in 56 % of children, almost 90% of them had otitis media [10]. A specific viral infection (e.g., croup, bronchiolitis, varicella, roseola) was identified in an additional 4% of children [10]. Similarly, 6% of 21,216 children 3 to 36 months of age with fever ≥39ºC seen in the emergency department of an urban tertiary care children's hospital had a recognizable viral syndrome, 47% had fever without source (FWS), and 47% had a specific bacterial infection [11].

In one series (prior to the introduction of Haemophilus influenzae type b (Hib) and pneumococcal conjugate vaccines) of 996 febrile children less than 36 months of age, <1% had meningitis, 10% had focal soft tissue infections, and 30 percent had pneumonia [12,13].

One of the key tasks in both hospital ER and primary-care settings is, therefore, to distinguish children who may have serious infections (e.g. meningitis, bacteremia) or complications from infection (e.g. hypoxia from bronchiolitis, dehydration from gastroenteritis) from the vast majority with self-limiting or minor infections that can safely be managed at home. Approximately half of children with meningococcal disease are missed in the first consultation with a doctor, which results in a poorer health outcome [5]. There are several triage systems currently in use in ER. These are primarily designed to assess level of urgency for care, rather than as diagnostic tests for serious infections. The Manchester Triage System assigns the patient to one of five categories based on the maximum time that a patient can wait for full assessment. It provides only modest sensitivity (63%) to detect emergency or very urgent cases, and is a generic instrument designed to deal with emergencies including trauma [14]. Other triage systems used internationally include the Emergency Severity Index, the Pediatric Canadian Triage and Acuity Scale, the Pediatric Risk of Admission Score and the Pediatric Emergency Assessment Tool. A number of more specific 'scoring systems' for children presenting to ER with medical illness have been developed. None has shown sufficient ability to rule out serious infection in children to be widely adopted in a National Health Service context [15-18].

MATERIALS AND METHODS

A descriptive cross-sectional hospital-based study conducted at Bahry Teaching Hospital, Khartoum, Sudan, from February 2012 to August 2012. The pediatric ER received 130 patients daily. Children presented to the ER with acute febrile illness age >1month - < 16yrs were included. Sample size was 150 and calculated according to the equation:

Sample size $= \frac{Z^2 \times P \times q}{e^2}$

Where,

Z: is the value of the standard normal variable corresponding to 95% confidence level

P: is the proportion of patients with acute febrile illness in the EDs (P= 0.2), q = 1-P=0.8

e: is a margin of error (e= 0.004096)

Sample size = (1.96×1.96 × (0.2×0.8)) ÷ 0.004096= 150

Data on presenting clinical symptoms and signs (including vital signs; temperature, pulse rate respiratory rate, blood pressure, oxygen saturation and capillary refill time), laboratory indices, and final diagnosis were collected from the study population after informed consent.

Each child's outcome has been classified as SBI (Serious Bacterial Infection) or not SBI after a detailed review of clinical and laboratory data. SBI is defined as admission to hospital plus any of the following (in the absence of an alternative non-infective or non-bacterial diagnosis to explain the clinical and laboratory findings): positive bacterial cultures from blood or another normally sterile site in the appropriate clinical context; radiological signs of pneumonia; clinical meningitis plus a cerebrospinal fluid polymorph nuclear leukocytosis; acute febrile purpura; deep collection(s) requiring intravenous antibiotics ± surgical drainage or a final diagnosis of septic arthritis, osteomyelitis, empyema or mastoiditis. Data entry and analysis were done using SPSS version 19.

RESULTS

The children enrolled in the study were divided into 3 age groups, 20.7% patients were less than 1 year old, 38% patients were 1-5 years old and 40.7% patients were more than 5years old. More than half (52.7%) of patients were males and 47.3% were females. Fever was present in 100% of patients, cough in 50%, sore throat in 18.7%, diarrhea in 17.3%, vomiting in 18.7%, dysuria in 2.7% and convulsion in 0.7% of patients. On examination 38% of patients were looking well, 55.3% were looking ill and 5.7% of patients were looking very ill.

Vital signs results were as follow: Temperature: 47.3%of patients were having temperature < 38c°, 44% had temperature 38 - 39.9 c° and 8.7% had temperature of 40 c° or more. Pulse rate: 78% of patients had normal pulse rate while 22% of patients had tachycardia. Systolic blood pressure: Normal blood pressure measured in 98.7% of patients while 1.3% of patients were hypotensive. Oxygen saturation: 88 % of patients had oxygen saturation of 95-100%, 10.7% patients had oxygen saturation of 90-94 % and 1.3% patient had oxygen saturation of <90%. Respiratory rate: 76.7% of patients had normal respiratory rate while 23.3% of patients were tachypniec. Capillary refill time: 98.7% of patients had capillary refill time of <2 seconds while 1.3% patients had capillary refill time of >2 seconds.

Reported diagnoses were: Tonsillitis 43.3%, Gastroenteritis 18.7%, Malaria 8.7%, 4- common cold 7.3%, Pneumonia in 6.6%, Otitis media 8%, Bronchiolitis 1.9%, UTI 1.3%, Meningitis 1.3%, Abscesses 2% and Herpetic stomatitis 0.7% patients (Figure 1). The overall classification of patients revealed that 10% had serious bacterial infections and 90% had no serious bacterial infections.

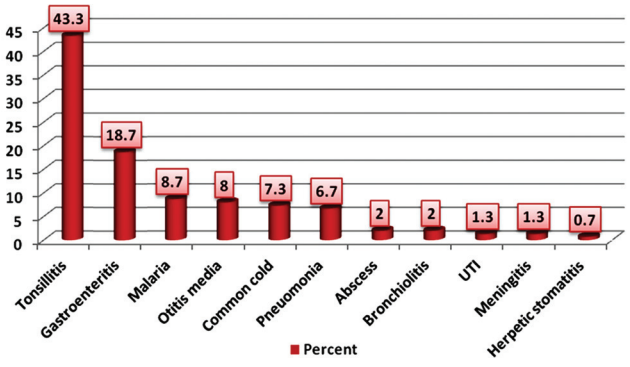

Figure 1 - Percentage of different diagnoses in patients

When inferential work was done using cross tabulation and regression tests, there was statistical significance when testing the general look of the patient on presentation with the final classification p-value of 0.00 (Table 1).

Table 1- Association between general look of the patient and disease classification (P-value 0.00)

		General look of the patient			
		Well	**Ill**	**Very ill**	**Total**
Classification	Serious bacterial infection	1	8	6	15
	Not serious infection	56	75	4	135
Total		57	83	10	150

Tachycardia and tachypnea are the most sensitive and specific in predicting serious bacterial infections with sensitivity (80%, 86.6 %) and specificity (97.4%, 83.7%) respectively, high temperature, severe hypoxemia and hypotension were the least sensitive but highly specific for serious bacterial infections (Table 2).

Table 2- Predictive values of different vital signs for serious bacterial infection

Variable	Sensitivity%	Specificity%	PPV	NPV	LR+	LR-
Temperature <38	6.7	48.1	1.4	82.2	0.21	1.93
Temperature 38-39.9^{O} C	53.3	68.1	12.1	92.9	1.67	0.69
Temperature=or >40 ^{O}C	40	94.8	46.1	93.4	7.69	0.63
Tachycardia	80	97.4	63.3	97.4	30.7	0.21
Hypotension	6.7	99.2	50	90.5	8.4	0.94
Mild hypoxemia 90-<95	53.3	94.1	50	94.7	9.03	0.49
Severe hypoxemia<90	13.3	100	10	10.3	0.13	86.7
Tachypnea	86.6	83.7	37.1	98.2	5.3	0.16
CRT>2S	6.7	99.2	50	90.5	8.4	0.94

DISCUSSION

In this study 10% patients were classified as having serious bacterial infections, with pneumonia in 6.6%, meningitis in 1.3%, Urinary Tract Infections (UTI) in 1.3% and deep abscess in 0.7%. These results are comparable to those in Australia study in which the prevalence of serious bacterial infections of interest (pneumonia, UTI and bacteremia) was 7.2% [18].

Vital signs were studied in all patients and their predictive values for serious bacterial infections were calculated. Temperature of 38-39.9 found to haev moderate sensitivity and specificity (53.3%, 68.1%) respectively and low PPV (12.1%) but high NPV (82.2%). This finding is similar to a study in England in which temperature of >38.5 showed sensitivity, specificity, PPV and NPV of 37.8, 84.8, 9.2 and 97.1 respectively. Also a study done in Nottingham showed predictive value of fever >38.5C for meningococcal diseases similar to that in our study of 58%, 81%, 27% and 94% for sensitivity, specificity, PPV and NPV respectively [19].

Also similar findings in M. Thompson et al were

that having one or more of temperature > of =39 degrees, Oxygen saturations <or=94%, tachycardia and tachypnea was 80% sensitive and 39% specific for serious or intermediate infection [14]. This was comparable to the MTS score (84% sensitive, 38% specific), and the NICE traffic light system (85% sensitive, 29% specific). Whereas temperature = or > 40 in our study showed high specificity and NPV (97.4 and 93.4) respectively, is not tested in other studies.

Tachycardia showed significant predictive value; sensitivity, specificity, PPV and NPV of (80%, 97.4%, 63%and 97.4%) respectively. This is similar to England study in which sensitivity, specificity, PPV and NPV (63.9%, 60.9%, 6.0% and 97.7%) respectively [15]. Although tachycardia is cofounded by the fact that pulse rate increase with increasing temperature but the performance of the temperature–pulse centile charts in another study done in England compared with pulse centile and APLS defined tachycardia was disappointing. There was no strong evidence of an association between temperature–pulse centile category and risk of SBI, reflected in the poor sensitivity, specificity, PPVs, NPVs, LR+ and LR− of individual centile cut-offs in their study. Importantly, although imperfect, the corresponding age group-specific centile ranges for pulse alone was more strongly associated with SBI, and the simpler APLS definition of tachycardia was a better predictor of SBI. This is perhaps not surprising, since bacterial infection causes fever, which in turn increases the pulse rate, so that increased temperature positively confounds (is at least part of the explanation) the observed association between increased pulse rate and SBI. One would therefore expect any adjustment for the effect of temperature (eg, using the temperature–pulse centiles) to reduce the strength of this association.

Hypotension has very low sensitivity (6.7%) but high specificity and NPV (99.2 and 90.5) respectively; this is similar to England study, which showed sensitivity, specificity, PPVs, NPVs (0.0%, 99.8%, 0.0%, and 96.2%) respectively. In Nottingham study, hypotension PV is also similar to our study, which showed 28%, 97%, 71% and 84% of sensitivity, specificity, PPVs, NPVs respectively. The low sensitivity of hypotension could be due to the fact that hypotension appear late in the course of the disease. The other thing in our study and also in England study, very ill patients who need immediate intervention were excluded and this would further reduce sensitivity as those were expected to have hypotension.

Hypoxemia is a known manifestation and complication of pneumonia and other SBI, in our study mild to moderate hypoxemia (95-100%) showed high specificity and NPV (94.1% and 94.7%), respectively (Table 1) but with moderate sensitivity 53.3%. This is similar to England[16] study in which high specificity and NPV (83.7% and 97.0 %), respectively, and low sensitivity of (33.8%). Severe hypoxemia < 90% showed even higher specificity and NPV (100% and 91.2%) this comparable to England study, which showed (97.0% and 96.6%) specificity and NPV respectively [16]. But severe hypoxemia has very low sensitivity in both studies.

Tachypnea is the most sensitive and specific sign of radiographically confirmed pneumonia in children [20,21]. In a systematic review evaluating the correlation between clinical examination findings and radiographic pneumonia, tachypnea was twice as frequent in children with or without radiographic pneumonia, and the absence of tachypnea was the single most valuable sign for excluding pneumonia [20].

CONCLUSION

Vital signs are important in predicting serious bacterial infections among children with acute febrile illnesses. Tachycardia and tachypnea are the most sensitive and

specific signs in predicting serious bacterial infections. High temperature equal to or > 40 ^{O}C, severe hypoxemia < 90% oxygen saturation and hypotension were the least sensitive but highly specific for serious bacterial infections. Raising-up the awareness and knowledge about importance of measuring vital signs among medical personal, by lectures and workshops, are highly recommended.

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