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Pediatrics 1985;76:167-171

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Predictive Value of Abnormal Physical Examination Findings in Ill-Appearing and Well-Appearing Febrile Children

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ABSTRACT. In order to study the occurrence and positive predictive value of history and physical examination findings suggestive of serious illness in ill-appearing and well-appearing febrile children, 103 consecutive children aged ≤ 24 months with fever $\geq 38.3^\circ\text{C}$ were evaluated from July 1, 1982 to Nov 24, 1982. Patients were initially classified by an attending physician (A) as to whether they appeared ill (Yale Observation Scale score >10) or well (scale score ≤ 10). The history was then taken by two attending physicians (A and B) and a resident; the physical examination was performed by attending physician B and the same resident. As history and physical examination findings were elicited, they were scored as to whether they did or did not suggest a serious illness. Serious illness was defined as the presence of a positive laboratory test. Ill-appearing patients had a significantly greater ($P < .001$, Fisher's exact test) occurrence of physical examination findings suggesting serious illness (14 of 22, 64%) than well-appearing children (12 of 81, 15%). The positive predictive values of abnormal physical examination findings for serious illness in ill-appearing (11 of 14, 79%) and well-appearing children (3 of 12, 25%) were significantly different ($P = .02$ by Fisher's exact test). The trends for abnormal history findings in ill-appearing and well-appearing children were similar to those for abnormal physical examination findings but did not achieve statistical significance. The results, indicating an important interaction between a febrile child's appearance and physical examination findings, are discussed in terms of probability reasoning in clinical decision making. *Pediatrics* 1985;76:167-171; fever, clinical judgment, diagnosis, toxicity, Bayes theorem.

Recent studies have demonstrated the association between a febrile child's appearance and the

presence or absence of serious illness.¹⁻³ No studies have investigated the interaction between a febrile child's appearance, history, and physical examination findings and the presence of serious illness. In order to investigate selected aspects of this interaction, we asked the following questions: First, do ill-appearing febrile children more frequently have history and physical examination findings that suggest a serious illness than well-appearing children? Second, do ill-appearing febrile children with abnormal history and physical examination findings more often have a serious illness as defined by a positive laboratory test than well-appearing febrile children with abnormal findings?

Our data indicate that there is an important interaction between a febrile child's appearance and physical examination data and that appearance influences the positive predictive value of abnormal physical examination findings for serious illnesses.

METHODS

A consecutive series of infants aged 24 months or less with temperature 38.3°C or greater coming to our Primary Care Center-Emergency Room from July 1, 1982 to Nov 24, 1982 were enrolled in the study. The study was conducted from 8 AM to 5 PM Monday through Friday. Eligible children were identified by the head nurse in either of the two locales.

Children were initially observed by an attending pediatrician (P.L.M. and referred to as attending physician A) and classified as to whether they appeared ill or well. A history was then taken by a resident pediatrician, who served as the prime questioner, and two attending physicians A and B. Attending physician B was one of six emergency room attending physicians. The physical examination

Received for publication April 9, 1984; accepted Aug 27, 1984. Presented, in part, at the Annual Meeting of the Ambulatory Pediatric Association, Washington, DC, May 5, 1983. Reprint requests to (P.L.M.) Department of Pediatrics, Yale University School of Medicine, 333 Cedar St, New Haven, CT 06510. PEDIATRICS (ISSN 0031 4005). Copyright © 1985 by the American Academy of Pediatrics.

was performed by attending physician B and the pediatric resident independently; as history and physical examination findings were elicited, they were noted by attending physician A on a blank lined form and scored as to whether they did or did not suggest a serious illness. If disagreements arose between attending physician B and the resident about the presence of a physical examination finding that suggested a serious illness, the child was reexamined simultaneously by these two physicians; only those abnormal findings which on reexamination these physicians agreed were present were considered present. If the disagreement persisted, the finding was considered equivocal and not present.

The Yale Observation Scales were used to judge whether a child appeared ill or well.¹ The Scales are shown in the Figure. These scales have previously been shown to be valid and reliable in identifying serious illness in febrile children by observation. As noted above, the scales were scored by attending physician A prior to the history and the physical examination; the child was seated on the parent's lap. If a child had a Yale Observation Score greater than 10, he or she was defined as ill appearing; if the score was 10 or less, the child was said to be well appearing. Previous work¹ has shown that if the scale score is greater than 10, the chance

of a serious illness is 40%; if the scale score is 10 or less, the chance of a serious illness is 2% to 3%.

After the observation, history, and physical examination, the resident made the decision about performing laboratory studies. The resident had the opportunity to discuss the advisability of laboratory studies with the two attending physicians if he or she so wished.

For the purposes of the study, a serious illness was defined as an illness associated with one or more of the following abnormal laboratory results: (1) a bacterial pathogen isolated from the CSF, blood, urine, stool, deep soft tissue, or pleura; (2) an infiltrate seen on chest roentgenogram, aseptic CSF pleocytosis, or abnormal serum electrolyte values such as hypernatremia or acidosis; or (3) hypoxemia (as documented by an arterial $PO_2 \leq 70$ mm Hg) during a lower respiratory tract infection.

Previous work indicates that this definition includes the vast majority of seriously ill febrile children.¹

Children were followed by the appropriate attending physician or resident until the illness resolved and study patient charts were reviewed by one of us (P.L.M.) 1 to 6 months after the visit in order to monitor the occurrence of serious illness in study patients.

The difference in the frequency of patients with

Observation Item	1 Normal	3 Moderate Impairment	5 Severe Impairment
Quality of Cry	Strong with normal tone OR Content and not crying	Whimpering OR Sobbing	Weak OR Moaning OR High pitched
Reaction to Parent Stimulation	Cries briefly then stops OR Content and not crying	Cries off and on	Continual cry OR Hardly responds
State Variation	If awake → stays awake OR If asleep and stimulated → wakes up quickly	Eyes close briefly → awake OR Awakes with prolonged stimulation	Falls to sleep OR Will not rouse
Color	Pink	Pale extremities OR Acrocyanosis	Pale OR Cyanotic OR Mottled OR Ashen
Hydration	Skin normal, eyes normal AND Mucous membranes moist	Skin, eyes-normal AND Mouth slightly dry	Skin doughy OR tented AND Dry mucous membranes AND/OR Sunken eyes
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)

Figure. The Yale Observation Scales.

history or physical examination findings suggesting serious illness among ill-appearing versus well-appearing febrile children and the difference in the frequency of patients with laboratory-documented serious illnesses among ill-appearing febrile children with abnormal clinical findings, versus well-appearing febrile children with abnormal clinical findings were studied using Fisher's exact test.

RESULTS

During the study period, 103 febrile children were evaluated: 73% of the 103 patients were seen by two attending physicians and a resident; 23% of the 103 patients were seen by one attending physician, who performed the observation, history, and physical examination, and a resident; 4% of the patients were seen by one attending physician only. Analyses of both the entire study group ($N = 103$) and those patients seen by two attending physicians ($N = 75$) yielded similar results. Therefore, analysis of the entire study group is reported.

Of the 103 children evaluated, 22 appeared ill and 81 appeared well. The following data focus on the frequency of physical examination findings suggesting serious illness in ill-appearing and well-appearing children and the positive predictive value of those findings. The number of patients with physical examination findings suggesting serious illness among ill-appearing versus well-appearing children is as follows. Of 22 ill-appearing children, 14 (64%) had physical examination findings suggestive of a serious illness; of 81 well-appearing children, 12 (15%) had physical examination findings suggestive of a serious illness. These differences are significant $P < .001$ by Fisher's exact test.

The physical examination findings suggesting a serious illness among the 14 ill-appearing children and 12 well-appearing children with abnormal findings are shown in Tables 1 and 2.

The number of patients with laboratory-documented serious illnesses among ill-appearing children with physical examination findings suggesting a serious illness versus among well-appearing children with physical examination findings suggesting a serious illness is as follows. Of 14 ill-appearing children with physical examination findings suggesting a serious illness, 11 (79%) had a documented serious illness, ie, the positive predictive value of an abnormal physical examination finding for a documented serious illness in an ill-appearing child was 79%. Of 12 well-appearing children with physical examination findings suggesting a serious illness, three (25%) had a documented serious illness, ie, the positive predictive value of an abnormal physical examination finding for a documented serious illness in a well-appearing child was 25%. The

TABLE 1. Physical Examination Findings Suggesting Serious Illness in Ill-Appearing Children

No. of Patients	Findings	Illness Suggested
3	Tachypnea*	Pneumonia
1	Tachypnea, rales, grunt	
1	Tachypnea, rales, retractions	
4	Nuchal rigidity	Meningitis
1	Full fontanel	
1	Buccal induration, erythema	Deep soft tissue infection
1	Leg erythema, swelling	
1	Bloody diarrhea	Enteric pathogen
1	Mottled, gray color	Sepsis

* Respiratory rate ≥ 40 /min in children older than 3 months of age (the two study children aged 3 months or younger with tachypnea had respiratory rates of 100/min and 60/min, respectively)

TABLE 2. Physical Examination Findings Suggesting Serious Illness in Well-Appearing Children

No. of Patients	Findings	Illness Suggested
2	Tachypnea*	Pneumonia
1	Tachypnea, hyperpnea	
1	Tachypnea, rales	
1	Tachypnea, retractions	
1	Tachypnea, prolonged expiration	
1	Retractions	
2	Rales	
1	Rhonchi	Meningitis
2	Full fontanel	

* Respiratory rate ≥ 40 /min in children older than 3 months of age (the two study children aged 3 months or younger with tachypnea had respiratory rates of 100/min and 60/min, respectively).

positive predictive value of abnormal physical examination findings in ill-appearing and well-appearing children is significantly different ($P = .02$ by Fisher's exact test).

These results are not due to a differing frequency of laboratory studies performed to investigate abnormal physical examination findings in the two groups. Significant differences persist between the positive predictive value of abnormal physical examination findings in ill-appearing and well-appearing children if only those patients who had laboratory studies performed to investigate the abnormal findings are considered. Of 13 ill-appearing children with positive findings who had a laboratory study performed to investigate the finding, 11 (85%) had a laboratory-documented serious illness; of eight well-appearing children with positive findings who had a laboratory study performed to in-

investigate the finding, three (37%) had a laboratory-documented serious illness. This difference continues to be significant at $P < .04$ by Fisher's exact test.

When the 75 patients evaluated by two attending physicians and a resident (and hence in whom the independence of observation data and physical examination findings is assured) are considered as a separate group, the results are similar to those presented above for the 103 patients in the total study: The occurrence of abnormal physical examination findings in ill-appearing and well-appearing children was 50% and 10%, respectively, and the positive predictive value of these findings for laboratory-documented serious illness was 71% (5/7) in ill-appearing children and 0% (0/7) ($P < .05$) in well-appearing children.

A similar analysis was performed for historical findings in ill-appearing and well-appearing children as was performed for physical examination findings. The trends were similar to those for physical examination findings but did not achieve statistical significance.

DISCUSSION

When evaluating an individual patient with fever, the clinician uses certain diagnostic tests, such as the peripheral WBC count or the chest roentgenogram, in order to discern the probability of an underlying illness such as bacteremia or pneumonia. Given a positive (or negative) test result, the clinician can then determine the likelihood of disease in the patient using Bayes formula which permits calculation of the posttest (or a posteriori) probability of disease on the basis of three factors: (1) the pretest (or a priori) probability that the patient has the underlying disease; (2) the sensitivity of the diagnostic test; and (3) the specificity of the diagnostic test.^{4,5}

The pre-test (a priori) probability of disease is the clinician's best estimate of disease in the patient under evaluation based on clinical data, such as signs and symptoms, prior to performance of the test.^{4,5} The sensitivity of the test is the proportion of patients with disease in whom the test result is positive. The specificity of the test is the proportion of patients without disease in whom the test result is negative.

The a posteriori probability of a disease given a positive test result is represented by the percentage of all positive test results that are "true positive" and reflects the predictive value of a positive test. Alternatively, the a posteriori probability of a disease given a negative test result is represented by the percentage of all negative test results that are "true negative" and reflects the predictive value of a negative test.

The importance of the a priori probability of disease in the calculation of the posttest probability of disease using Bayes formula is illustrated by Khan and Khan.⁵ These authors have demonstrated that the a posteriori probability of ankylosing spondylitis in adults who have a positive result on HLA-B27 testing (sensitivity = 0.92, specificity = 0.92) rises from 10% to 92% when the clinician's a priori probability estimate based on clinical data rises from 1% to 50%.

Although not diagnostic tests, the history and the physical examination are clinical diagnostic maneuvers to which Bayesian analysis may be applied. For example, one may calculate the a posteriori probability of pneumonia in any one patient given the presence of rales on chest auscultation during the physical examination based on the clinician's a priori estimate of pneumonia prior to examination and the sensitivity and specificity of rales for pneumonia. In analogous fashion, a probability estimate of serious illness may be made in a febrile child after the history and the physical examination, and this a posteriori probability is directly influenced by the clinician's best estimate of serious illness (premaneuver probability) prior to the history or the physical examination. How is this premaneuver probability estimated?

Traditionally, as Pantell et al⁶ argue, the probability of serious illness in the febrile child prior to physical examination is estimated on the basis of epidemiologic data such as the child's age and the height of the core temperature. Specifically, age less than 3 months and/or fever $\geq 40^{\circ}\text{C}$ (104°F) set a high preexamination probability of underlying serious illness such as septicemia, pneumonia, or meningitis. Recent work by others suggests that the a priori probability of serious illness in febrile infants aged 24 months or less may be set by the child's overall appearance, which the clinician assesses by interacting with the child prior to the history or the physical examination.¹ One such study has demonstrated that an ill-appearing febrile child has a higher probability of serious illness (40%) as opposed to a well-appearing febrile child (2% to 3%).¹

The present study has examined the interaction between a febrile child's appearance, the results of the traditional clinical diagnostic maneuvers of history and physical examination, and the presence of serious illness. We have demonstrated that febrile children who appear ill by the Yale Observation Scales more often have physical examination findings that suggest a serious illness than febrile children who appear well. We have further demonstrated that the posttest or a posteriori probability of abnormal physical examination findings for serious illness in a febrile child, that is, the positive

predictive value of abnormal physical examination findings in a febrile child, is directly influenced by the a priori or pretest probability of serious illness which is based on the child's appearance. The current data indicate that an ill-appearing febrile child with abnormal physical examination findings almost always has a serious illness (11 of 14 cases [79%]). Conversely, the well-appearing child with abnormal physical examination findings much less frequently has an underlying serious illness (3 of 12 cases [25%]). Therefore, the period of interaction between a febrile child and a pediatrician prior to the history and the physical examination serves not only to comfort the child and the parents but also allows the pediatrician to set an a priori probability of serious illness and to interpret the subsequent history and physical examination data in light of that probability.

The data reported in this study by no means indicate that positive physical examination findings in the well-appearing child should be ignored. As noted above, the occurrence of serious illness in well-appearing children is 2% to 3%¹ and rises to 25% when abnormal physical examination findings are present. Medical decision making should be based on an appreciation of the complex interaction of the many sources of data available to the physician.⁷ One such interaction is that between appearance and physical examination findings. Appreciation of that interaction should, in turn, influence such decisions as test ordering and management plans.

Our study results also have implications for the design of studies investigating the value of selected clinical findings, such as respiratory signs⁸ or signs of meningeal irritation,⁹ in febrile children. A child's appearance should be evaluated as well as the clinical finding in question. If study patients were made comparable in appearance as well as the presence or absence of a selected finding such as tachypnea, then one potential source of discrepant positive predictive values for such a finding would be eliminated.

Future work will continue to explore the inter-

action between a febrile child's appearance, history, and physical examination findings.

IMPLICATIONS

The period of time prior to the history and physical examination during which an experienced pediatrician comforts and interacts with the child is reassuring to the parents and beneficial to the child. It is also a time when the pediatrician is creating an a priori probability framework; within that framework, he or she will conduct and interpret the history and physical examination. Thus, this time is among the most important in pediatric practice.

ACKNOWLEDGMENT

This work was supported, in part, by a General Pediatric Academic Development Award from the Robert Wood Johnson Foundation.

We thank Howard Pearson, MD, for his support, the Pediatric Housestaff and Outpatient Nursing Staff for their cooperation, and Barbara Serphillips for typing the manuscript.

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