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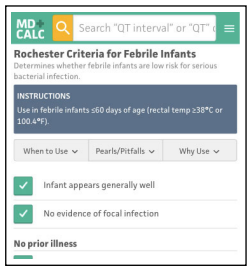

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Rochester Criteria for Febrile Infants

The Rochester criteria for febrile infants determine whether or not febrile infants are at low risk for serious bacterial infection.

Points & Pearls

- While the validation study for the Rochester criteria included infants aged ≤ 60 days, in clinical practice, infants aged < 28 days often are not considered to be at low risk, due to their age.
- Premature infants should be assessed based on their corrected age (eg, for an infant born at 30 weeks gestational age, subtract 7 weeks from the chronologic age).

Evidence Appraisal

The Rochester criteria were first proposed by Dagan et al in 1985 at the University of Rochester Medical Center in New York. In 1994, Jaskiewicz et al validated the criteria by aggregating data from 3 prospective studies that were conducted between 1984 and 1992. Only infants aged ≤ 60 days who had rectal temperatures ≥ 38°C (100.4°F) at home or at presentation were included in the validation study. The clinical environments were an emergency department and a pediatric outpatient clinic.

The evaluation of each infant included global assessment, past medical history, physical examination (including for evidence of skin, soft tissue, bone, or joint infection), and laboratory assessment (including blood, urine, and cerebrospinal fluid studies). Chest x-ray and stool studies were only obtained if clinical symptoms were present. Of note, cerebrospinal fluid studies were not part of the Rochester risk stratification criteria. Each infant was then categorized as low risk or not low risk. Among 931 evaluable patients, 437 met all of the low-risk criteria and 511 did not.

The study's main outcomes were bacteremia and a larger inclusive category of serious bacterial infection (SBI). SBI was defined as bacteremia, meningitis, osteomyelitis, suppurative arthritis, soft tissue infections (cellulitis, abscess, mastitis, omphalitis), urinary tract infection, gastroenteritis, or pneumonia. SBI was identified in 1% of the low-risk infants as compared to 12.3% of non–low-risk infants. The negative predictive value (NPV) of the low-risk criteria was 99.5% for bacteremia and 98.9% for SBI.

In 2012, Hui et al conducted a review of 84 studies to determine the diagnostic accuracy of screening tools for SBI and HSV in infants aged < 3 months. This review also examined the relationship between viral testing and risk of SBI. The various clinical and laboratory criteria (including the Rochester, Philadelphia, Boston, and Milwaukee screening tools) demonstrated similar overall accuracy (84.4%-100% sensitivity; 93.7%-100% NPV) for identifying infants with SBI. The Rochester criteria were more accurate in neonates than in older infants, while the other screening tools were more accurate in older infants than in neonates.

In 2016, Gomez et al conducted a prospective study including infants aged < 90 days who presented to 11 European pediatric emergency departments between September 2012 and August 2014. The study compared the accuracies of the new Step-by-Step approach, the Rochester criteria, and the Lab-score for identifying patients who are at low risk of invasive bacterial infection (IBI). For

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the study population, the sensitivity and NPV for ruling out IBI were 92.0% and 99.3%, respectively, for the Step-by-Step approach, 81.6% and 98.3% for the Rochester criteria, and 59.8% and 98.1% for the Lab-score. Some infants with IBIs were misclassified by each of the tools in the study: 7 by the Step-by-Step approach,16 by the Rochester criteria, and 35 by the Lab-score.

Use the Calculator Now

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Calculator Creator

Ron Dagan, MD
Click here to read more about Dr. Dagan.

Why to Use

- The Rochester criteria identify infants who are at low risk for SBI (defined as bacteremia, meningitis, osteomyelitis, suppurative arthritis, soft tissue infections [cellulitis, abscess, mastitis, omphalitis], urinary tract infection, gastroenteritis, or pneumonia).
- Febrile infants aged ≤ 60 days may present with minimal signs and symptoms or may present similarly to those who have viral infections. The criteria can help identify SBI in these patients; the prevalence of SBI is 10% to 12% in this group, with urinary tract infections representing > 90% of these SBIs (Biondi 2013, Greenhow 2014).
- Use of the Rochester criteria may reduce overtesting and overtreatment of well-appearing febrile infants.

When to Use

- The Rochester criteria can be used for well-appearing infants aged ≤ 60 days who present to the ED for a chief complaint of fever ≥ 38°C (100.4°F), or who are found to have fever on presentation for another complaint.
- Ill-appearing infants should be redirected to the sepsis guidelines.

Next Steps

If the patient is at low risk for SBI according to the Rochester criteria (in the derivation study, SBI occurred in 1% of low-risk infants):

- Limited testing, including complete blood cell count, blood culture, urinalysis, and urine culture, is recommended.
- Febrile infants who are considered to be at low risk generally do not require antibiotics.
- It is generally safe to discharge these infants if there are no social concerns or questions about the caregiver's ability to follow up with a primary care pediatrician.

If the patient is not considered to be at low risk for SBI according to the Rochester criteria (in the study, SBI occurred in 12.3% of infants who were identified as not at low risk):

- Further testing is required, including complete blood cell count, blood culture, urinalysis, urine culture, and cerebrospinal fluid testing.
- Empiric broad spectrum antibiotic coverage is indicated.
- Admission is recommended, pending negative cultures at 24 to 36 hours.

Advice

- Herpes simplex virus risk factors should be carefully assessed, including maternal history of herpes simplex virus infection or primary lesions at delivery, household contacts with lesions, vesicular rash, patient presentation with seizures, or pleocytosis on cerebrospinal fluid testing.
- A positive viral test result (eg, respiratory syncytial virus, influenza) reduces the likelihood of SBI by approximately 50%, but the risk of a concurrent SBI is not 0% (Greenhow 2014, Krief 2009).
- The gold standard for urine culture is a sample obtained via straight catheterization. "Bag" urine collection introduces the risk of specimen contamination with skin flora. If possible, blood, urine, and cerebrospinal fluid samples should be obtained before starting antibiotics.
- The differential diagnosis of febrile ill-appearing infants aged < 60 days should also include the following: congenital heart disease, metabolic disease (eg, galactosemia), congenital adrenal hyperplasia with adrenal crisis, and nonaccidental trauma.

Abbreviations: ED, emergency department; SBI, serious bacterial infection.

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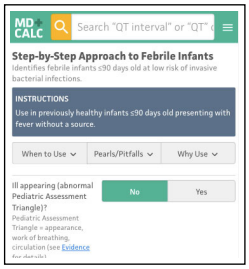

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Step-by-Step Approach to Febrile Infants

The Step-by-Step approach to febrile infants identifies febrile infants aged ≤ 90 days who are at low risk for invasive bacterial infections.

Points & Pearls

- The Step-by-Step approach was developed with the goal of identifying febrile infants aged ≤ 90 days who are at low risk of invasive bacterial infection (defined as bacteremia or meningitis).
- It was only studied in previously healthy infants and does not apply to infants who have any prior medical history.
- The Step-by-Step approach should be used in previously healthy infants aged ≤ 90 days who present with fever without a source.
- In the original study by Mintegi et al (2014), "fever without a source" was defined as fever in an infant with an unremarkable physical examination and without signs or symptoms of a self-limiting viral illness such as bronchiolitis or gastroenteritis.
- Differences in the prevalence of invasive bacterial infection (IBI) versus noninvasive bacterial infection in each risk subgroup should also be taken into consideration when interpreting and applying the results of the original study.
- The Step-by-Step approach performs best when applied to infants with fever lasting > 2 hours because the rule relies on the detection of inflammatory markers (procalcitonin and C-reactive protein) that may take time to increase.

Critical Action

No decision rule should trump clinical gestalt. High suspicion for IBI in a febrile infant should warrant a full sepsis workup.

Evidence Appraisal

Gomez et al (2016) conducted a prospective validation study of previously derived criteria, which they applied to 2185 infants aged ≤ 90 days who presented to pediatric emergency departments at 11 European hospitals. Among this group, 3.9% were diagnosed with an IBI and 19.1% were diagnosed with a noninvasive bacterial infection such as urinary tract infection.

In a post-hoc analysis, the Step-by-Step approach demonstrated superior sensitivity and negative predictive value as compared to other risk assessment tools such as the Rochester criteria and the Lab-score (Shaughnessy 2016). Sensitivity and negative predictive value for ruling out IBI were 92.0% and 99.3% for the Step-by-Step approach, 81.6% and 98.3% for the Rochester criteria, and 59.8% and 98.1% for the Lab-score, respectively.

Use the Calculator Now

Click here to access Step-by-Step on MDCalc.

Calculator Creator

Santiago Mintegi, MD, PhD.
Click here to read more about Dr. Mintegi.

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Original/Primary Reference

- Mintegi S, Bressan S, Gomez B, et al. Accuracy of a sequential approach to identify young febrile infants at low risk for invasive bacterial infection. *Emerg Med J.* 2014;31(e1):e19-e24. **DOI: https://doi.org/10.1136/emermed-2013-202449**

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Why to Use

The etiology of fever in infants aged ≤ 90 days can range from self-limiting viral illness (eg, bronchiolitis) to life-threatening IBI (eg, bacteremia or meningitis). The Step-by-Step approach can be used to rule out IBI with a high negative predictive value (99.3%). If IBI can be safely ruled out, these low-risk infants do not require hospital admission and intravenous antibiotics.

When to Use

- The Step-by-Step approach can be used in previously healthy infants aged ≤ 90 days who have a fever ≥ 38.0°C (≥ 100.4°F) documented at home or at presentation in the ED.
- Caution is advised when using the Step-by-Step approach in infants with a short duration of fever, as it takes time for serum inflammatory markers (eg, procalcitonin, to increase). Observation in the ED should be considered, even if laboratory values are initially normal.
- Caution is advised when using the Step-by-Step approach in infants aged 21 to 28 days, as the management of this age group remains controversial and the Step-by-Step algorithm did not perform optimally in this group. In the validation study by Gomez et al (2016), 4 out of the 7 patients (57%) who were not identified as high risk by the Step-by-Step approach but were diagnosed with an IBI were aged 21 to 28 days. Studies suggest that the prevalence of bacteremia may be higher in infants aged 21 to 28 days as compared to infants aged > 28 days, so a full sepsis workup is recommended for any infant aged < 28 days (Powell 2018).

Next Steps

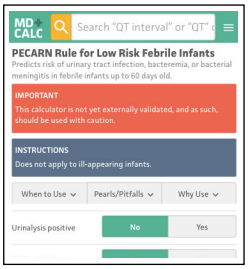
Interpretation

Risk Group	IBI Risk	Recommendation
Low	0.7%	Full sepsis workup is likely not needed. Consider a period of ED observation, especially if the fever lasts < 2 hours, and ensure outpatient follow-up with a pediatrician.
Intermediate	3.4%	Full sepsis workup (including blood, urine, and cerebrospinal fluid cultures), initiation of broad-spectrum intravenous antibiotics, and inpatient hospital admission may be indicated, especially if the patient is aged 21 to 28 days.
High	8.1%	Full sepsis workup (including blood, urine, and cerebrospinal fluid cultures), initiation of broad-spectrum intravenous antibiotics, chest x-ray, and inpatient hospital admission are recommended.

Management of IBI in Infants:

- Prompt initiation of broad-spectrum antibiotics according to local guidelines is strongly recommended.
- Optimization of respiratory support and hemodynamics should be initiated if respiratory distress or signs of dehydration or shock are present.
- Inpatient hospital admission for a minimum of 36 to 48 hours is recommended if cultures remain negative. Studies indicate that if IBI is present, 96% of blood cultures will become positive within 36 hours and 99% will become positive within 48 hours (Biondi 2014, Biondi 2015).

Abbreviations: ED, emergency department; IBI, invasive bacterial infection.



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PECARN Rule for Low-Risk Febrile Infants

The PECARN rule for low-risk febrile infants predicts the risk for urinary tract infection, bacteremia, or bacterial meningitis in febrile infants aged ≤ 60 days.

Points & Pearls

- The PECARN (Pediatric Emergency Care Applied Research Network) prediction rule does not apply to ill-appearing infants. The rule is intended to be one directional: it may help rule out serious bacterial infection (SBI) in patients who are "low risk," but the converse is not true (ie, patients who are "not low risk" according to the rule do not necessarily have an SBI).
- Infants with signs of shock or who are otherwise ill-appearing or unstable should be considered at to be at high risk for SBI and in most cases should have blood, urine, and cerebrospinal fluid cultures performed. This clinical prediction rule would not apply to such patients.
- A serum procalcitonin level is required for the PECARN prediction rule, but this test may not be rapidly available in all settings.
- The majority of infants aged ≤ 60 days are unvaccinated and have immature immune systems.
- Infants aged < 28 days warrant special attention, as they are at elevated risk for herpes meningoencephalitis as well as a more rapid progression of disease. These patients almost always require admission for close monitoring along with a full sepsis workup, including lumbar puncture.

Critical Actions

Consider a critical congenital heart defect (and empiric prostaglandin treatment) in a neonate who presents in shock.

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Evidence Appraisal

The derivation study by Kuppermann et al (2019) included 1896 previously healthy febrile infants aged ≤ 60 days who had a serum procalcitonin level test at the time of their sepsis evaluation; participants whose procalcitonin samples were lost or mislabeled were excluded. The overall cohort was 1821 patients (908 in the derivation sample and 913 in the validation sample). The primary outcome was the presence or absence of an SBI, defined as urinary tract infection, bacteremia, or bacterial meningitis.

The prediction rule had a sensitivity of 98.8% (95% confidence interval [CI], 92.5%-99.9%) in the derivation study and 97.7% sensitivity (95% CI, 91.3%- 99.6%) in the validation study. The negative predictive value for SBI was 99.8% (95% CI, 98.8%-100.0%) and 99.6% (95% CI, 98.4%-99.9%) in the derivation and validation studies, respectively. Because the validation study was not conducted independently, there is a risk of diminished external validity.

The benefits of using this rule are: (1) unnecessary admissions may be decreased and (2) unnecessary lumbar punctures may be avoided. A key difference in this prediction rule as compared to other similar rules is that the sensitivity remained high despite the fact that lumbar puncture results were not used as criteria in the rule. However, there is a low prevalence of bacterial meningitis in the general population due to the use of *Haemophilus influenzae* type B and pneumococcal vaccinations, so there were few cases of bacterial meningitis included in this study's data set.

Finally, 3 infants in the study were misclassified by the prediction rule as being at low risk but had SBIs (2 had a urinary tract infection and 1 had *Enterobacter cloacae* bacteremia). All 3 were treated appropriately based on culture results and had uneventful clinical courses.

Use the Calculator Now

Click here to access the PECARN rule on MDCalc.

Calculator Creator

Nathan Kuppermann, MD, MPH
Click here to read more about Dr. Kuppermann.

Why to Use

A physical examination alone is unreliable in ruling out SBI in febrile infants. The PECARN prediction rule may help to decrease unnecessary admissions and/or lumbar punctures. It can be used to help determine the disposition of some well-appearing infants who have reliable access to follow-up with a primary care pediatrician or in the same ED in 24 hours, or whose caregivers can be relied upon to return the patient to the ED if a pending culture has a positive result.

When to Use

Use the PECARN prediction rule in well-appearing infants aged ≤ 60 days, to stratify the risk of SBI (defined as urinary tract infection, bacteremia, or bacterial meningitis).

Next Steps

- Patients predicted to be at low risk for SBI might be able to be safely discharged from the ED, as long as follow up with a primary care pediatrician or in the same ED can be reasonably well assured.
- The decision to admit a febrile infant is multifactorial. Lack of reliable follow-up care may necessitate admission.

Advice

Some well-appearing infants considered to be at low risk for SBI may be suitable for discharge from the ED with follow-up with their primary care pediatrician or in the same ED in 24 hours for reassessment, as opposed to the traditional practice of admitting all febrile infants aged 0 to 60 days.

Abbreviations: ED, emergency department; PECARN, Pediatric Emergency Care Applied Research Network; SBI, serious bacterial infection.

Reference

Original/Primary Reference

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