Diagnosing Infection in a Neonate Using Whole-Body Screening Magnetic Resonance Imaging

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abstract

The location of invasive infections is difficult to detect in infants, in part due to their inability to localize signs and symptoms. However, identifying the location often significantly alters clinical management by extending the duration of antibiotic therapy or revealing a source requiring surgical intervention. Compared with commonly used first-line imaging techniques such as radiographs and ultrasounds, MRI has higher sensitivity for identifying invasive infections and allows for simultaneous evaluation of multiple foci. We present 2 cases in which whole-body screening MRI was used in neonates to identify invasive sources of infection, including one in which traditional modalities failed to detect multiple clinically significant sources. We posit that whole-body screening MRI merits consideration as a potential first-line imaging method when investigating invasive infections in infants.

There is a high risk of infection in the newborn population. Preterm infants have an even greater risk of infection than their term counterparts due to a more immature immune system, prolonged hospitalizations, and multiple invasive procedures and indwelling devices. Although infections are commonly recognized in infants, identifying the source can be challenging, especially without localizing signs or pain. However, identification of an invasive infection such as a soft tissue infection, osteomyelitis, septic arthritis, or a surgical site infection can influence clinical management by extending the duration of antibiotic therapy or revealing the potential need for surgical intervention.

Currently, radiographs, ultrasonography, and computerized tomography (CT) scans are the most common imaging modalities used to detect invasive infections. Clinically significant radiographic findings are generally limited to skeletal abnormalities, and radiographs have poor sensitivity for locating invasive infections such as osteomyelitis in neonates.[1] The sensitivity of ultrasonography is unknown in infants, and because whole-body ultrasonography is impractical, the success of this modality depends on the clinician recognizing the correct anatomic site to study. CT scans offer the ability to image multiple sites but require increased radiation exposure and administration of potentially nephrotoxic contrast media. To move past these limitations, we present 2 cases of newborns in which whole-body screening MRI was used as an alternate method to detect multifocal infection.

RESULTS

Case 1

The infant was the older sibling of twins born at 23 and 5/7 weeks, with

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Dr Fu conceptualized the case report; and Drs Fu and Kingma co-drafted the initial manuscript and reviewed and revised the manuscript collectively. Both authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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a birth weight of 604 g. On day of life 7, she developed *Escherichia coli* bacteremia that was treated, but on day of life 26, purulent drainage was noted upon removal of a left axillary peripherally inserted central catheter. The infant was started on vancomycin and tobramycin, and her blood culture specimen grew both *E coli* and methicillin-resistant *Staphylococcus aureus* (MRSA). The *E coli* cleared after 1 day of antibiotic treatment, but MRSA continued to grow from daily blood culture specimens despite drainage of a clinically detected right thigh abscess on day of life 28. Her cerebrospinal fluid was also positive for MSRA. She required a high dose of vancomycin (70–72 mg/kg/d) to maintain trough levels of 15.6 to 19.1 μg/mL. In addition, the minimum inhibitory concentration of the MRSA strain was low, suggesting high susceptibility. The infant received 2 doses of adjunctive linezolid with no improvement. An evaluation was performed on days of life 32 to 34 to assess for occult infection, but no source of infection was found; that is, no abscess on head or abdominal ultrasound, no vegetation on echocardiogram, and no osteomyelitis changes on radiographic skeletal survey. After 8 days of bacteremia, the patient was transferred for further evaluation on day of life 34.

At the referral NICU, rifampin was added for synergy, and the infant's first negative finding on blood culture was reported on day of life 35. She also underwent whole-body screening MRI on day of life 35, which revealed multiple findings on T1-weighted, T2-weighted, and short TI inversion recovery sequences despite no clinical correlating signs on physical examination: a large right hip effusion with synovial thickening causing subluxation of the femoral head; a small left hip effusion; 2 foci of osteomyelitis in the left femur and right tibia; chondritis of the right femoral epiphysis; and a large right neck abscess involving the parotid gland. On day of life 36, needle aspiration of both hip effusions and the parotid abscess was performed, and results of the cultures were positive for MRSA from the right hip and parotid drainage. She received a total of 42 days of vancomycin to treat the osteomyelitis. In follow-up, the infant had persistent right hip subluxation and epiphyseal chondrolysis, with no signs of further infection (Fig 1).

Case 2

The infant was a large-for-gestation 38-week male born at 4040 g who experienced perinatal asphyxia and a humerus fracture secondary to shoulder dystocia at delivery. He received therapeutic hypothermia for hypoxic-ischemic encephalopathy but was transferred on day of life 6 because of concerns regarding seizures. A small pressure ulcer along his posterior scalp was noted before transfer, and on day of life 8, the ulcer released a significant amount of purulence. Wound and blood culture specimens grew MRSA, and the infant was started on vancomycin. On day of life 9, the infant's fracture site developed swelling, and an abscess was confirmed by using ultrasound. The abscess and associated osteomyelitis, diagnosed operatively based on bony involvement within the wound, required debridement by orthopedics multiple times. Daily blood culture specimens persistently grew MRSA for >1 week despite vancomycin therapy. He underwent whole-body screening MRI to determine other sources of infection; the MRI confirmed the previously diagnosed osteomyelitis, but no additional foci were identified. His first negative result on blood culture was reported on day of life 19, after 10 days of antibiotics and the addition of rifampin for synergy. The infant received a total of 79 days of intravenous antibiotics.

DISCUSSION

The majority of neonatal infections are treated without identification of the pathogen or the primary site of infection. However, in cases involving an unrecognized invasive or multifocal infection or a localized infection that requires surgical intervention, identification of the occult source may improve medical management. We report 1 case in which whole-body screening MRI located multiple sites of clinically significant infection and a second case in which MRI confirmed that the infection was isolated to a previously recognized site of osteomyelitis.

In the first case, traditional imaging modalities such as radiographs and ultrasound failed to identify any of the 6 sources of infection (an additional site was identified by external examination, and the site was subsequently drained on infant day of life 28). The sensitivity and specificity of radiographs and ultrasound for detecting invasive infections in the pediatric population are uncertain.[1] Radiographs are inexpensive and readily available, but their findings often lag behind clinical findings by 1 to 3 weeks,[1–4] particularly in cases of osteomyelitis; this lag may delay intervention and negatively affect outcomes in a critically ill infant. Ultrasound is also accessible, but the success of this procedure is operator-dependent and relies on identification of the anatomic site of infection, which is challenging because the signs of infection in neonates are broad, nonspecific, and nonlocalizing. As with our first case, there were no external signs of infection in 6 of the 7 sites, resulting in failure to investigate those sites by using ultrasound.

The sensitivity and specificity of bone scintigraphy, CT scans, and MRIs are likely higher than radiographs and ultrasounds, but these values are difficult to determine and rarely reported in children and neonates.

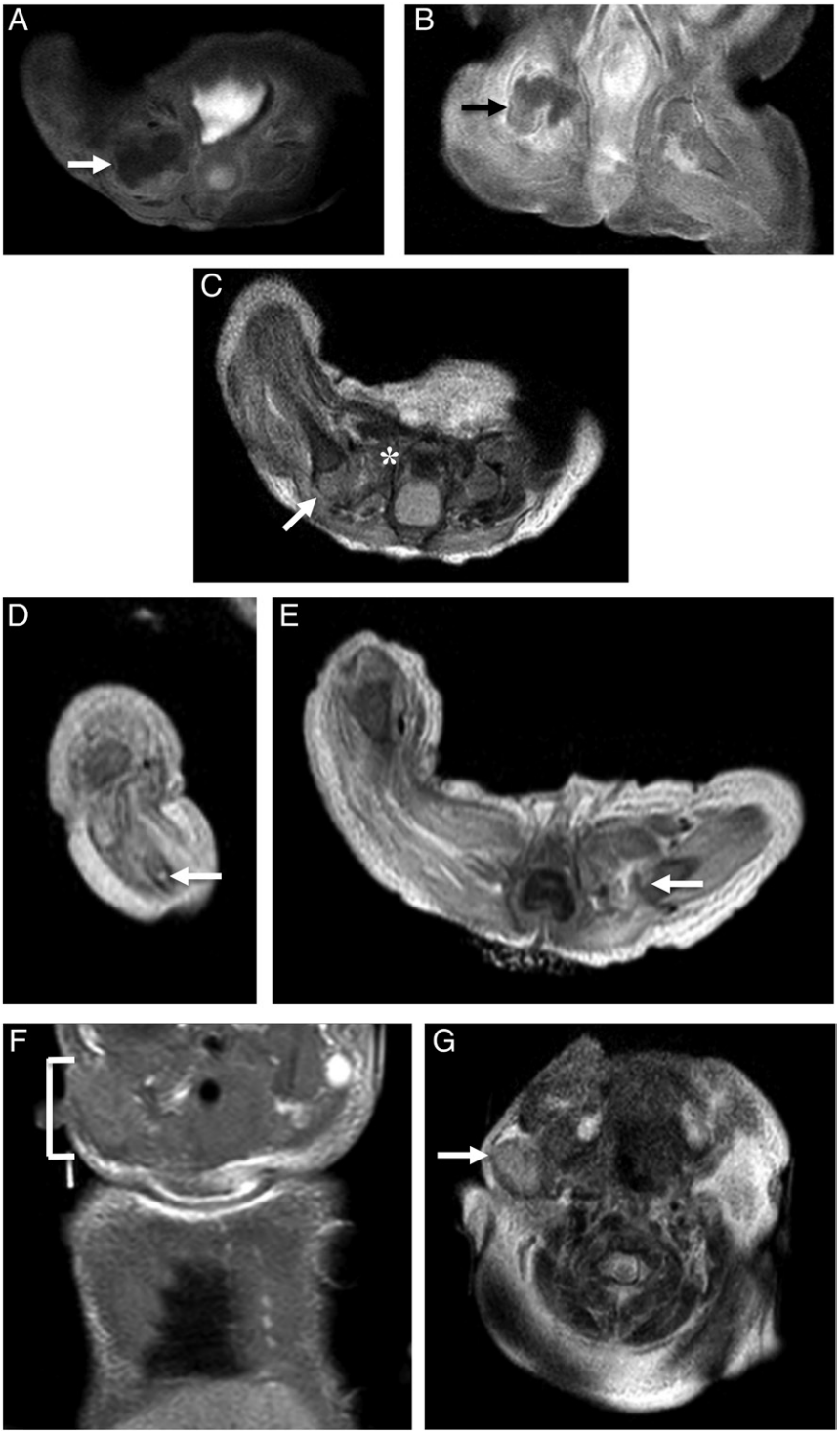

FIGURE 1
MRI from case 1 showing (A) axial T1-weighted, (B) coronal T1-weighted, and (C) axial T2-weighted sequences of the right hip effusion measuring 13.1 × 17.9 × 13.2 mm. Note the displacement of the femoral head (arrow) away from the acetabulum (asterisk) in (C). Short TI inversion recovery sequences identifying osteomyelitis in (D) the right tibia and (E) the left femur. Parotid abscess measuring 17.5 × 14.0 × 13.8 mm is shown on the (F) coronal T1-weighted and (G) axial T2-weighted sequences.

As with radiographs, scintigraphy is limited to identifying skeletal abnormalities but with potentially improved sensitivity at 32% to 100%.[1,3,4] However, false-negative findings are frequently reported because isotopes may concentrate at the active epiphysis of the growing infant, which may be difficult to distinguish from an adjacent site of infection. In addition, blood supply and resultant isotope uptake may be diminished by the presence of purulence in the infected bone.[1, 3] CT and MRI scans allow clinicians to evaluate multiple body sites simultaneously, and studies in adults suggest that the 2 modalities have sensitivities for detecting osteomyelitis at 67% and 82% to 100%, respectively.[1] In a pediatric study of osteomyelitis caused by *S aureus* (ie, the predominant pathogen in that age group), MRI had a sensitivity of 99% compared with 53% with bone scintigraphy, 20% with radiographs, and 0% with ultrasounds.[5] Furthermore, more than one-half of the children had extraosseous complications identified only on MRI, 92% of which required additional intervention. Although these studies did not use whole-body screening MRI, which is a rapid variant protocol that utilizes a limited number of sequences, whole-body screening MRI has been shown to have sensitivities and properties comparable to traditional focused MRIs.[6] In situations similar to our second case, in which MRI did not detect additional sources of infection, the high negative predictive value of the MRI (89%–100% in pediatric patients with acute osteomyelitis[2]) increases the likelihood that all sources of invasive infection have been identified. MRI has the additional benefits of avoiding exposure to radiation and potentially nephrotoxic contrast material and producing better and earlier visualization of soft tissue details,[1,6] including edema and inflammation, that may arise before development of

bony changes or fluid collections.[1,3] Due to these advantages, whole-body screening MRI has found some use in the pediatric population, particularly in oncologic cases to detect bone marrow lesions, but it also has the potential for use in evaluating inflammatory and infectious etiologies.[6,7]

Although our 2 cases illustrate the potential benefits of using whole-body screening MRI to identify invasive infections, this technique is not without limitations. The cost of MRI is a frequent concern, but earlier detection of an invasive infection may recover MRI costs by reducing complications and length of hospital stay. Additional analysis is needed to assess the cost–benefit of MRI compared with other modalities. Furthermore, not all hospitals have easy access to an MRI machine and, unlike our institution, where an MRI scanner is present in the NICU, most hospitals would require transport of the critically ill neonate outside of the NICU. One other major concern is the duration of time required to conduct an MRI, which may necessitate more sedation and expose the infant to prolonged stress. This time may be magnified by scanning multiple body sites; however, by utilizing only select sequences such as T1-weighted, T2-weighted, and short TI inversion recovery, whole-body screening protocols reduce the total scan time to 45 to 60 minutes. In addition, our MRI staff has implemented a "feed and swaddle" technique that pacifies neonates during scans and often reduces the need for sedation.

Our experience illustrates the potential of whole-body screening MRI to identify multifocal invasive infections. Although supporting evidence in larger populations is limited, our 2 cases suggest that this approach deserves consideration as a first-line method for investigating invasive infections in infants.

ABBREVIATIONS

CT: computerized tomography
MRSA: methicillin-resistant *Staphylococcus aureus*

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