It's All Fun and Games Until Somebody Shoots His Eye Out

A previously healthy 6-year-old boy was playing with a BB gun he received for his birthday and was accidentally shot in the left temple. His mother immediately cleaned the barely visible wound; however, within a few hours, the boy began to feel unwell and had several episodes of emesis. In the emergency department, a computed tomography scan revealed that the BB was lodged in the parenchyma of the left parietal region, and a small subdural hematoma had formed. He underwent immediate neurosurgery to evacuate the hematoma, but the BB could not be safely removed. He received perioperative cefazolin and tolerated the initial surgery well.

Postoperatively, the infectious diseases service was consulted with the question of the necessity for further antibiotics. The consulting physician noted that this question had no definitive answer in the literature because no relevant randomized controlled trials exist. He referred to retrospective and observational prospective studies but felt that data on infection with a retained foreign body were sparse. Given the uncertainty and the potential for a brain abscess or meningitis, the consultant rendered the opinion that the benefits of a long course of broad-spectrum antibiotics outweighed the risks. He ultimately recommended intravenous vancomycin and meropenem for a minimum of 6 weeks. A peripherally inserted central catheter (PICC) was placed on hospital day 5, and the patient was discharged from the hospital with plans to follow up in the infectious disease clinic for weekly laboratory evaluations to monitor for infection or antibiotic adverse effects.

Six days after discharge, the patient was readmitted for high fever and loose stools. His head computed tomography scan showed no intracranial complications, and his inflammatory markers were normal. Results of infectious testing were negative; these tests included a viral respiratory panel, *Clostridium difficile* toxin assay, Epstein-Barr virus and cytomegalovirus titers, and blood cultures. The patient was diagnosed with a presumed viral infection and discharged from the hospital to continue his prescribed antibiotics.

After an additional 10 days, the patient was readmitted for a second time (now 3 weeks into the planned antibiotic course) for persistent fever, diffuse pruritic rash, and mild facial and upper extremity edema. At this time, he had a low white blood cell count with 10% eosinophils and mildly low hemoglobin and low albumin levels. The remainder of the test results were normal, including inflammatory markers. A drug reaction was the presumed diagnosis, and the infectious disease team was consulted to discuss stopping the empiric antibiotics. A different infectious disease physician was on-call at this time, and after reviewing the case

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ABBREVIATIONS
PCCI: penetrating craniocerebral injury
PICC: peripherally inserted central catheter

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and the literature, he felt that the risks of continuing the antibiotics exceeded the harms; the antibiotics were therefore discontinued. At this point in the clinical course, the patient's upper extremity swelling had worsened and was painful. A thrombus at the PICC line site was diagnosed. The PICC was promptly removed, and treatment was initiated with low-molecular-weight heparin. The patient improved rapidly, the rash cleared, and the fever resolved. He was discharged from the hospital with the plan to complete a 3-month course of low-molecular-weight heparin, which unfortunately precluded him from participating in his upcoming soccer season.

On a daily basis, physicians are required to make difficult clinical decisions in the absence of high-quality evidence to help guide those decisions. This case was no exception. The physicians were trying to prevent a potentially serious complication, such as a brain abscess or meningitis, which could have been devastating, but how likely was that outcome? Do prophylactic antibiotics truly prevent that outcome and, if so, what is the optimal antibiotic choice, route, and duration? How does the risk of infection compare with the risk of having an adverse event from long-term intravenous antibiotics or central venous access?

Infection rates resulting from penetrating craniocerebral injuries (PCCIs) were reportedly as high as 59% in World War I, before the use of antibiotics. More recently, with the routine use of antibiotics and advanced surgical techniques, the rates of infection have ranged from 4% to 11% in military conflicts and 1% to 5% in civilian settings.[1] Much of the literature on the subject comes from military conflicts, which may not apply to this civilian case. Military injuries are often due to high-velocity weapons, whereas civilian injuries in pediatric populations are frequently due to low-velocity impact. Children, more so than adults, are the typical victims of gunshot wounds from weapons that derive their energy source from compressed air or carbon dioxide (eg, air rifles, BB guns).[2,3]

The treatment of PCCIs is prompt surgical debridement and wound closure. It is generally accepted that bullets or bone fragments that are deep and difficult to retrieve are left in place to prevent further injury to the brain during surgery.[4,5] The concern is that the presence of retained foreign bodies will increase the risk of infection, and although there is some conflicting evidence on this matter, it seems the risk of infection is not large with retained bone or metal fragments.[6,7] The civilian literature more commonly reports brain abscess after penetrating intracranial injuries from certain types of objects such as pencils or arrows, particularly if there is a retained piece of organic material (eg, wood, hair, cloth). Other risk factors for infection include wound dehiscence, cerebrospinal fluid leak, and injury through a sinus occupied with bacterial flora.[1,6,8]

There are no well-designed, double-blinded, randomized trials addressing optimal antibiotic use in PCCIs. The actual microbiology of PCCI infections is not fully characterized, as many studies omit culture data and other studies do not differentiate between colonization and actual clinical infection. The main causative agents seem to be gram-positive cocci, namely *Staphylococcus* and occasionally *Streptococcus*, and gram-negative rods, such as *Klebsiella* and *Acinetobacter*. Anaerobes such as *Clostridium* may play a role as well.[1,4]

Given the wide range of potential pathogens, broad-spectrum antibiotics are often recommended, but the antibiotic courses reported in the literature vary. A survey of US neurosurgeons in 1991 found that 59% of respondents used a cephalosporin for 4 to 10 days in the majority of cases.[9] A comprehensive review of antibiotic use in PCCIs was published in the United Kingdom in 1999. This review recommends either intravenous amoxicillin/clavulanic acid or intravenous cefuroxime with oral metronidazole, to be started as soon as possible after the injury and given for a total of 5 days postoperatively.[4] A more recent prospective cohort study found no difference in infection rates when prophylactic antibiotics were used.[10] However, this study was not randomized and was likely confounded by selection of the dirtiest wounds for treatment.

The risks associated with antibiotic administration are often underappreciated. The patient discussed here was at significant risk because he was exposed to 2 antibiotics and had a central catheter for a long course of antibiotics. A prospective cohort study in which 2574 PICCs were placed in 1807 children found that the rate of complications necessitating catheter removal was 20.8%. Complications included accidental dislodgement, infection, occlusion, infiltration, leakage, breakage, phlebitis, and thrombosis.[11] In a smaller retrospective study of 98 children in California receiving outpatient parenteral antimicrobial therapy, a similar rate of catheter-associated complications was found (26%).[12] This study also reported antibiotic-associated complications in 11% of their population; the most common was neutropenia, followed by rash, drug fever, and eosinophilia.

It is impossible to predict whether the current patient would have developed an infectious complication from his injury had he received a shorter course, a narrower spectrum, or even no further antibiotics. However, based on the available literature, the chance of infection was likely low. He was a civilian shot with a BB that did not pass through a sinus or orbit, the retained projectile was metal (not organic material), he sought care quickly and had prompt surgical management, and he did not have a cerebrospinal fluid leak or wound dehiscence, all of which put him in a low-risk category. What is known is that without a PICC line, he would not have developed a thrombus, and with a shorter course of antibiotics, a drug reaction would have been less likely. Although the physician team clearly had the best interest of the patient in mind, the interventions he received likely caused more harm than good, which makes this case an example of low-value care.

As physicians, we struggle with risk estimation. We are inherently biased to overestimate certain types of risk and to underestimate others.[13] Even after the complications that ensued in the present case, most physicians involved saw them as an unfortunate necessity. This view is probably not supported by a true reckoning of the risks and benefits associated with the choices made but rather highly influenced by our inherent psychological biases. Physicians labor under the broad assumption that our job is to assure an eventual good outcome by using treatment. Unfortunately, we have no rubric for assigning value to the harm not done by not treating. This fact makes learning from cases such as the current one all the more valuable.

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