Air Physiogram: Technique for Visualization of the Resected Physis in Percutaneous Epiphysiodesis

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Abstract: Obtaining an air physiogram improves visualization of the resected physis and allows the surgeon to assess whether a sufficient amount of growth plate has been removed during percutaneous drilling epiphysiodesis. From 2008 through 2011, the air physiogram technique was used in 37 percutaneous epiphysiodesis procedures about the knee (17 femora, 20 tibiae) in 31 children. Average follow-up was 41 months (range, 19-70 months). Thirty-six of 37 limb segments achieved radiographic fusion after the initial procedure. One tibia appeared to be partially fused and underwent revision epiphysiodesis. At final follow-up, all limb segments had successful epiphysiodesis and showed radiographic evidence of fusion. [Orthopedics. 2015; 38(3):170-174.]

Epiphysiodesis is commonly recommended for approximately 2 to 5 cm in children and adolescents.1,2 Phipps3 described the original technique as an open procedure. However, since Bowen and Johnson’s4 1984 article on this topic, a shift has occurred toward percutaneous techniques.5-8 Advantages of percutaneous surgery include a smaller incision with a less noticeable scar, a shorter recovery time, and decreased pain.8 Disadvantages are decreased visualization of the physis by the surgeon and the need for image intensification.2,9 Techniques for percutaneous drill epiphysiodesis are diverse. Surgeons differ in the tools that they use before curettage (ie, drills vs reamers) as well as in the number of incisions they believe to be necessary (ie, single portal vs double portal). Numerous studies suggest that all of these methods are effective and have low morbidity and high success rates.2,5-10 Nonetheless, incomplete or asymmetric growth arrests do occur, resulting in failure of the epiphysiodesis and sometimes angular deformation.7,8

Some disagreement exists over how much of the physis must be removed to ensure growth arrest.1,2,11 The acceptable range seems to be from one-fourth to one-half of the physis.2,4,5,11 Erring on the side of removing more physis than less is preferred. It is difficult to adequately view the resected physis and to determine whether enough has been removed, even with the use of fluoroscopic image intensification during the procedure. Incomplete physeal resection can cause asymmetric growth arrest, partial growth arrest, or failure of growth arrest.2,4,5 To help minimize these complications, the current authors propose the air physiogram technique.

When a surgeon uses traditional non-contrast image intensification, bone fragments and blood remain in the area of the resected physis. The bone fragments and blood appear similar in radiologic density to...
the surrounding normal bone and physeal cartilage. With the authors’ technique, the bone fragments and blood are removed, leaving air in their place. This creates a clearly visible contrast, outlining the cave of resected bone and allowing the surgeon to more easily visualize the progress of his or her work. The authors believe that this technique may improve success rates and provide greater confidence in the percutaneous drill epiphysiodesis method.

**MATERIALS AND METHODS**

After institutional review board approval, the medical records of all patients who underwent treatment within a 4-year period (2008 through 2011) were retrospectively reviewed. The senior author (J.E.H.) used the air physiogram technique to perform 37 percutaneous epiphysiodesis procedures about the knee in 31 children (16 boys, 15 girls). The average age was 11.6 years (range, 7-15 years) at the time of the procedure. Thirty-two limbs underwent the technique, with a total of 20 proximal tibial and 17 distal femoral epiphysiodesis procedures performed. Five patients underwent the procedure in both the femur and the tibia of the same limb. Deformities resulted from congenital hemimelias (15 patients), clubfoot (2 patients), congenital posteromedial bow (4 patients), growth arrest (3 patients), Blount disease (1 patient), limb-length discrepancy (1 patient), multiple hereditary exostoses (1 patient), poliomyelitis (1 patient), sacral agenesis (1 patient), septic hip (1 patient), and previous osteomyelitis resection (1 patient).

**SURGICAL TECHNIQUE**

The surgeon routinely obtains an air physiogram of the femur or tibia during percutaneous epiphysiodesis but not of the fibula because it is such a small bone. For epiphysiodesis of the distal femur or proximal tibia and fibula, the surgeon should position the patient supine with a tourniquet at the mid-thigh. An image intensifier (C-arm) should be draped and positioned on the opposite side. The authors prefer to make a lateral single-portal incision and then use cannulated reamers and curettage to destroy a portion of the physis.

The lateral edge of the growth plate was located with image intensification, and a Steinmann pin was placed next to the knee as a marker. A 1.5-cm incision was made next to the physis, midway front to back in the sagittal plane. The surgeon dissected down to the physis with a straight hemostat. A 3/32-inch (2.4-mm) smooth Stein-
mann pin was inserted into the physis, and the curves of the lappets on the growth plate were bisected to ensure proper placement. The pin should be in the middle of the physis front to back. The pin’s position was confirmed on a cross-table lateral view. If the surgeon is dissatisfied with the pin’s position, he or she should either reposition it or insert a second, parallel pin at least 8 mm away (Figure 1).

Once the pin(s) were in place, they were drilled over with a cannulated 8-mm anterior cruciate ligament reamer. An angled curette was used to complete the destruction of approximately one-third of the physis anteriorly and posteriorly around the drilled hole(s) (Figure 2). Most of the curettage should be performed with a curette facing anteriorly and posteriorly. Multiple punctures (superiorly and inferiorly) may be made into the epiphysis and metaphysis to help stimulate arrest.

Next, the volume of resected physis was assessed with the image intensifier in the anteroposterior view using the air physiogram technique. To perform this technique, the physis was irrigated with saline and the bone fragments and fluid were then suctioned out. Only air was left behind, resulting in a much more definitive outline of the cavity created by the resection and allowing for a more accurate estimate of the volume of physis resected in the anteroposterior view (Figure 3). The air physiogram was obtained immediately after suctioning out the bone fragments and fluid because blood would have started to accumulate, obscuring the image. The irrigation and suction sequence was repeated and then a lateral view was immediately obtained (Figure 3). The lateral image intensifier view should be obtained in the cross-table lateral position. If additional curettage was deemed necessary, the surgeon continued to ablate the physis. Once it was confirmed that an adequate portion of the physis had been removed, the surgeon closed the incision.

RESULTS

Mean duration of follow-up was 41 months (range, 19-70 months). Thirty-six of the 37 limb segments showed...
evidence of radiographic fusion after the initial procedure. No partial growth arrests or angular deformities were observed. In 1 case, the tibia appeared to be partially fused 1 year and 8 months after the initial procedure. The patient was already scheduled to undergo an unrelated procedure; therefore, the surgeon elected to perform simultaneous revision epiphysiodesis of the right proximal tibia. Four months after the revision procedure, the tibia showed evidence of radiographic fusion. All limb segments had successful epiphysiodesis and showed radiographic evidence of fusion at final follow-up (Figure 4).

**DISCUSSION**

The inability to visually confirm adequate ablation during percutaneous epiphysiodesis has been a drawback to this technique. However, the advantages of the percutaneous method, including faster recovery time and reduced risks, made this drawback seem minimal. So how can the surgeon be confident that enough phy- sis has been resected?

The air physiogram technique is a quick additional step that may increase reliability for percutaneous drill epiphysiodesis. Its advantages include a lower risk of incomplete growth arrest, increased confidence in one’s surgical work, and increased reliability of complete epiphysiodesis.

Ghanem et al. recommend injecting dye into the resected region at the end of the procedure. They fail to provide studies, descriptions, or radiographic documentation to support their method. They do not discuss the type of dye used, the cost of the dye, or the allergic complications that could arise from use of the dye.

The current authors’ proposed air physiogram technique accomplishes the same goal as the dye proposed by Ghanem et al. but without the added cost or potential allergic complications. Suctioning out the debris leaves only air behind for a short period. The air physiogram takes advantage of the high contrast between bone and air on the image intensifier. While bone fragments and blood appear similar to the surrounding bone on the image intensifier view, the contrast between air and bone is much greater, making it easier to distinguish between them on the image intensifier (Figure 3). Within a few minutes, blood fills the cavity and the air leaves the wound.

Moreover, performing the air physiogram adds no cost to the procedure, as no supplementary materials are required, and the entire technique takes only a few minutes to complete. The technique allows the surgeon to use an air physiogram to make an informed decision about the status of the epiphysiodesis resection. Given the ease of use, lack of complications, and successful results, the authors recommend that surgeons consider using this technique when performing percutaneous drill epiphysiodesis.

**CONCLUSION**

The air physiogram technique is simple and effective and has no known complications. It improves the visualization of the resected physis during percutaneous drill epiphysiodesis, allowing for a more reliable assessment of the procedure. This technique could also be used in studies to test how much of the physis is sufficient for growth arrest, as this remains undetermined in the literature. Animal or cadaveric studies could also be conducted to compare the actual volumetric cavity size of the resection with the appearance of the cavity size after performing the air physiogram.

**REFERENCES**

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