# Ultrasonographic Confirmation of Intraosseous Needle Placement in an Adult Unembalmed Cadaver Model

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**Study objective:** Intraosseous access is widely used in pediatric and adult resuscitations when vascular access cannot be promptly established. Confirmation of intraosseous needle placement has traditionally relied on the ability to aspirate blood or marrow or infuse crystalloid easily. This study's aim is to determine the value of bedside ultrasonography as a means of confirming intraosseous needle placement by visualizing the flow of crystalloid within the intraosseous space.

**Methods:** A controlled trial was conducted in which intraosseous access was obtained in the bilateral distal tibia of 4 freshly frozen, unembalmed cadavers. In 8 legs, an intraosseous needle (15-gauge Jamshidi) was inserted 1 fingerbreadth superior to the medial malleolus and flushed with 10 mL of crystalloid. Measurements included whether crystalloid was observed to flow by gravity into the drip reservoir of the intravenous tubing and whether color flow was visualized within the intraosseous space of the tibia with a 5- to 10-MHz linear transducer in color power Doppler mode, positioned just cephalad to the intraosseous needle. Intraosseous needles were then intentionally placed into the subcutaneous space just posterior to the distal tibia, and these measurements were repeated. Two blinded observers reviewed ultrasonographic video recordings and rated the presence or absence of color flow within the intraosseous space.

**Results:** Intraosseous color flow on ultrasonography correctly identified all placements, but flow into the drip reservoir was incorrect for one of the intraosseous lines ($P=1.0$ versus ultrasonography) and 6 of the subcutaneous lines ($P=0.31$ versus ultrasonography). There was perfect interobserver agreement ($\kappa=1$) during video review.

**Conclusion:** In freshly frozen cadavers, ultrasonographic visualization of flow within the intraosseous space may be a reliable method of confirming intraosseous placement. The observation of flow into the drip reservoir appears to be an unreliable indicator of intraosseous placement in fresh frozen cadavers. [Ann Emerg Med. 2007;49:515-519.]

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## INTRODUCTION

### Background

Since the 1930s, intraosseous line placement has been a mainstay of therapy in pediatric resuscitation. In recent years, innovations in commercially available intraosseous devices have prompted a renewed interest in this technique in the out-of-hospital treatment of the adult population.[1-3] Emergency physicians place intraosseous lines when more traditional forms of venous access are unable to be obtained,[4,5] as dictated by advanced cardiac life support and pediatric advanced life support algorithms.[6] Intraosseous lines generally take seconds to place, are associated with few complications, and can be secured even in profoundly hypovolemic patients.[6,7] Despite the modest level of skill required, many clinicians report they are uncomfortable with placing intraosseous lines in an emergency setting.[8,9] Part of this discomfort may arise because there is no reliable method of confirming proper placement of the intraosseous needle in the cancellous bone of the target site.

Confirmation of intraosseous needle placement is achieved by observing the intraosseous needle's ability to stand upright without support, the ability to aspirate blood or marrow, or the ability to infuse crystalloid easily without visible extravasation or swelling.[10]

### Goals of This Investigation

We investigate the role of bedside ultrasonography in confirmation of successful intraosseous needle placement. We

**Editor's Capsule Summary**

*What is already known on this topic*

Intraosseous access is a useful alternative for fluid and medication administration when intravenous access cannot be obtained.

*What question this study addressed*

Whether ultrasonography with Doppler can confirm appropriate placement of intraosseous needles by demonstrating flow within the marrow space.

*What this study adds to our knowledge*

In this pilot study that compared intraosseous needles placed properly and in the subcutaneous space, ultrasonographic assessment of intraosseous flow had perfect sensitivity and specificity, whereas examination of the intravenous tubing drip chamber for flow had a sensitivity of 88% and specificity of 25%.

*How this might change clinical practice*

Clinicians might try ultrasonography for intraosseous line placement confirmation but should recognize that this small cadaver trial (N=8) is insufficient to establish the utility of this technique.

**Figure 1.** Ultrasonographic confirmation of intraosseous placement as performed by a single operator.

hypothesize that visualization of color flow within the cortex of the distal tibia will be observed when a correctly placed intraosseous needle is flushed with saline. Intraosseous needles placed intentionally in the subcutaneous space should not demonstrate color flow within the cortex of the bone.

## MATERIALS AND METHODS

After expedited review and approval from the Committee for Human Research, we conducted a controlled trial in which intraosseous needles were placed in the bilateral distal tibia of 4 freshly frozen, unembalmed cadavers. At each site, an intraosseous needle (15-gauge Jamshidi, Baxter Worldwide, Deerfield, IL) was inserted 1 fingerbreadth superior to the medial malleolus and flushed with 10 mL of normal saline solution. A 1-L bag of normal saline solution, positioned approximately 6 feet from the ground (2.5 feet from the cadaver), was then attached to the intraosseous needle with a standard 110-inch-long Baxter Continu-Flo adult intravenous tubing set (Baxter Worldwide, Deerfield, IL). The line was opened and the drip chamber was observed for continuous flow by gravity alone. Continuous flow was defined as drops of saline solution in the drip chamber at a rate greater than or equal to 1/second. A single investigator (N.A.T.) judged the flow rate and was blinded to the position of the intraosseous line. We then positioned a 5- to 10-MHz linear ultrasonographic transducer (Sonosite Micromaxx, Sonosite Inc., Bothell, WA) just cephalad to the intraosseous needle. While the machine was in color power Doppler mode, we recorded 15-second video clips to an external digital video disc (DVD) device as 3-mL aliquots of normal saline solution were infused (Figure 1). Intraosseous needles were then intentionally placed into the subcutaneous space just posterior to the distal tibia, and these measurements were repeated and recorded. DVD files were compiled in a random order by one of the investigators (M.B.S.). Two blinded investigators (N.A.T. and R.W.) independently reviewed the 16 recordings and qualitatively rated the presence or absence of flow within the cortex of the bone (Figures 2 and 3). Exact confidence intervals (CIs) for sensitivity (detecting correct placement) and specificity (detecting incorrect placement) for each method were obtained using the "cii" command in Stata 9.1 (StataCorp, College Station, TX). Matched comparison of the methods' sensitivity and specificity were performed with Stata's "mcci" command, which provides exact McNemar's test *P* values but only approximate CIs for differences in sensitivity and specificity.

## RESULTS

Seven of 8 (88%) of the intraosseous lines and 6 of 8 (75%) of the subcutaneous lines had free flow of crystalloid into the drip reservoir. All 8 (100%) of the intraosseous lines and none of the subcutaneous lines generated intraosseous color flow on ultrasonography. Test characteristics for both crystalloid flow and ultrasonographic flow were determined in reference to the criterion standard of intentional intraosseous or subcutaneous needle placement by experienced providers. Free flow of crystalloid as a means of confirming intraosseous placement in fresh frozen