

MAKERSPACE MODEL INSTRUCTIONS

Arizona Simulation Technology & Education Center

Advanced Ultrasound IV Trainer

1. INTRODUCTION

The Advanced Ultrasound Peripheral Line trainer allows educators to teach how to perform ultrasound-guided placement of intravenous (IV) catheters. There are four components to this trainer: the 3D printed mold, 3D printed base which acts as a structural support platform, ballistics gel simulating soft tissue, and the fluid circuit simulating blood vessels. This trainer is intended for experienced learners.

2. EQUIPMENT AND MATERIALS

- 3D printer with Polylactic Acid (PLA) filament¹
- Chemical fume hood²
- Multicooker¹
- Vacuum chamber¹
- Scale
- Bar clamp
- Hemostats (2)¹
- Paint brush
- Heat gun¹
- Clear Ballistics Gel #1 (1 L)
- Ballistics gel pigment - flesh tone (15 mL)
- 1/8" ID with 3/16" OD silicone tubing (1 ft)
- 1/12" ID with 1/4" OD silicone tubing (1 ft)
- 8 Fr Pediatric Stylet (2)
- Flex seal
- Ease release
- IV tubing, bag, and stand
- Heat protectant gloves

¹ These items are either optional or have substitutions. This is discussed below in each section.

² If you do not have a chemical fume hood, perform these steps in a well-ventilated area.

3. MOLD & BASE

The first step is to 3D print the mold and base.

MATERIALS:

- Flex Seal
- 3D printer with Polylactic Acid (PLA) filament³
- Paint brush

³These materials are required for making the mold base from a 3D printer. The mold and base could also be made using any rectangular container which has been modified to accommodate the silicone tubing.

We use the Ultimaker S7 Pro Bundle 3D printer with PLA filament. The print bed needs to be at least 10 by 10 inches. We have an .stl file available that can be used to print the mold, which takes 20 hours, and the base, which takes 10 hours.

After 3D printing is completed, spray the mold with Flex Seal under a chemical fume hood. Use the paint brush to ensure the surfaces are completely covered. Allow this to dry overnight.

4. SILICONE TUBING

The second step is to prepare the silicone tubing, which will simulate the blood vessels of the model.

MATERIALS

- Mold
- Ease Release
- Paint brush
- 8 Fr Pediatric Stylet (2)
- 1/8" ID with 3/16" OD silicone tubing (1 ft)
- 1/12" ID with 1/4" OD silicone tubing (1 ft)
- Hemostats (2)⁴

⁴ Hemostats are optional. If you find the vessels are moving once the ballistics gel is poured, the tubing can be secured by clamping with a hemostat on either side of the model.

The next day, under a chemical fume hood, spray the mold with Ease release. Use the paint brush to ensure the surfaces are completely covered. Allow this to dry for at least 5 minutes. The model is now ready to add the silicone tubing.

Cut about a foot of each size of silicone tubing. Bend the stylet to simulate the desired path of the vessels and insert into the tubing. The thicker walled tubing will simulate the artery and thinner walled will simulate the vein. String the tubing across the mold, making sure the tubing completely seals the holes in the mold.

Under the chemical fume hood, spray the tubing and mold with Ease Release. Use the brush to completely cover the surface of the tubing inside the mold. Allow this to dry for at least 5 minutes.

5. BALLISTICS GEL

The third step is to prepare the ballistics gel, which will simulate the soft tissue surrounding the blood vessels.

MATERIALS

- Mold with tubing
- Clear Ballistics Gel #1 (1 L)
- Flesh Tone Pigment (15 mL)
- Bar clamp⁵
- Heat protectant gloves
- Multicooker⁶

- Vacuum chamber
- Heat gun⁷

⁵The bar clamp is optional and can be used to secure the mold to your work surface while pouring the ballistics gel.

⁶Instead of a multicooker, the ballistics gel can be melted in an oven at 250°F, checking every 30 minutes to ensure the gel does not heat over 280°F.

⁷The heat gun is optional and can be used to remove bubbles from the surface of the model still present once the gel has cured.

A. MELTING

Break apart about 1 L of clear ballistics gel #1 into small pieces and place in the multicooker. In the chemical fume hood, turn on the multicooker to a temperature of 250-270°F. Add all the ballistics gel to the multicooker and allow to melt, stirring occasionally. It should take less than 5 minutes to completely melt.

Once the ballistics gel is completely melted, add 15 mL of the flesh tone pigment into the ballistics gel and stir until combined.

B. VACUUM CHAMBER

To remove all bubbles, place the entire multicooker into the vacuum chamber. Turn the vacuum chamber up to 40 kPa for three to five minutes. Return the multicooker to its heating source. Refrain from stirring, to avoid adding more air to the mixture. Evaluate the mixture by dipping a stir stick in and observing the number of bubbles. Repeat vacuum chamber and heating until bubbles are removed. This helps to ensure a high quality image under ultrasound, as any air left in the ballistics gel will increase image artifact.

Alternatively, if you do not have a vacuum chamber, you can bake the model after adding the pigment at 250°F until the bubbles are removed.

C. POURING BALLISTICS GEL

Once the ballistics gel is fully melted and bubbles are removed, use heat protectant gloves, and carefully pour the ballistics gel into the mold. Make sure the gel mixture completely fills the mold. Using a stir stick, quickly scrape off any remaining bubbles on the surface before the clear ballistics gel starts to cure. Allow the gel to fully set for a minimum of 12 hours. If after the gel has cured, there are more bubbles on the surface, we recommend using a heat gun to remove them before moving on.

6. ASSEMBLING THE BASE

The mold with tubing and cured ballistics gel is ready to be attached to the base.

MATERIALS

- 3D printed base
- Model with fluid circuit
- Z-Flex Tilt Tripod Head
- 20mm socket screw (2)
- Nuts (4)
- Washers (4)
- Bar clamp

The base in our setup is 3D printed and secured to an adjustable tripod head using washers, which is then clamped to the work surface for stability. However, this step does not need to be replicated exactly. Any setup that keeps the trainer stable and level during the training is acceptable. We encourage you to adapt this step using whatever materials are available to you.

7. CREATING A FLUID CIRCUIT

Once the ballistics gel has cured, the silicone tubing is ready to be connected to the IV tubing to create a fluid circuit.

MATERIALS

- Model base with tubing
- IV bag and tubing
- IV stand
- Water or simulated blood

To create the fluid circuit, you will need an IV bag, IV tubing, an IV stand, and the completed model with silicone tubing. The silicone tubing is connected to the IV tubing to establish a closed fluid circuit. The IV bag may be filled with water or simulated blood to replicate the "flash" or the confirmation of blood return that learners should observe upon correct catheter placement in the vein. As with the previous step, the materials used here can be adapted based on what is available to you.

8. CONCLUSION

Once the model is ready for use, place it on the base and begin imaging using an ultrasound machine. The image should show two vessels, one with a thicker wall simulating the arterial blood vessel, and one with a thinner, collapsible wall simulating the venous blood vessel.

This model provides the opportunity to practice ultrasound guided peripheral line placement. To clean and maintain the model, wipe off the ultrasound gel, and remove water from the vessels after use. The model can be stored at room temperature.

A. REUSING THE MODEL

This model can be reused with minimal additional materials. Once you have the mold and base created, it only takes one day to remake the model. Remove the ballistics gel and tubing from the model. Discard the used silicone tubing and save the ballistics gel to be reused. Repeat the above steps for adding silicone tubing. The old ballistics gel can be remelted and poured into the model. It is not necessary to add more pigment. Remove bubbles and allow to set as described above.

Use this link to view our instruction video:

<https://arizona.app.box.com/s/xp83j2ygc3wbyqusgq0lvphcn658g0f9>