How To: Create a cervical model for use in practicing fluoroscopically guided C1-C2 puncture

Materials (top left to bottom right):

- Alginate molding powder
- Round 2-liter soda bottle with top 1/3 removed and round hole cut at the bottom (we used 7up bottle)
- Red food coloring (liquid)
- Cervical spine model
- Occluding forceps/locking hemostat
- Latex tubing (1/2" ID, 5/8" OD)
- Spinal Needle (22G x 3.50 inch)
- PVC on/off valve
- Valve adapter
- Syringe for filling tubing and balloon
- Metal rod for placing inner balloon (this was created by cutting the bottom straight edge of a metal hanger)
- Long latex balloon
- Not pictured: Goof off adhesive remover
- Not pictured: screwdriver for screw removal from cervical spine model and pliers for rod removal
- Not pictured: dowel rod for replacement of metal support beam in cervical spine model
- Not pictured: Gorilla glue or other strong adhesive to attach rod and cervical spine model components

Links:

- Alginate Molding Powder: https://www.amazon.com/Create-Alginate-Molding-Powder-Casting/dp/B011MT6N7Q/ref=sr_1_3?crid=26TSWMBCBAW5S&keywords=luna+bean+alginate&qid=1656286549&s=arts-crafts&sprefix=luna+bean+alginate%2Carts-crafts%2C71&sr=1-3
- Cervical Spine Model: https://www.amazon.com/Cervical-Vertebra-Anatomical-Classroom-Teaching/dp/B07B5251YQ/ref=sr_1_3?crid=X1Y499GK8621&keywords=cervical+spine+model+unmounted&qid=1656286715&sprefix=cervical+spine+model+unmounted%2Caps%2C61&sr=8-3
- Occluding Forceps: https://www.amazon.com/dp/B08G8ZJ9ZC?psc=1&ref=ppx_yo2ov_dt_b_product_details
- Latex Tubing: https://www.mcmaster.com/catalog/128/157
- PVC on/off valve: https://www.mcmaster.com/catalog/128/499
- Valve adapter: https://www.mcmaster.com/catalog/128/196

- Syringe for filling tubing and balloon: https://www.amazon.com/gp/product/B07JZ2HMJ7/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1
- Long latex balloon: https://www.amazon.com/gp/product/B088FLRMWZ/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1
- Goof off adhesive remover (not pictured): https://www.amazon.com/Goof-Off-FG653-Professional-Strength/dp/B002MPPYYS/ref=asc_df_B002MPPYYS/?tag=hyprod-20&linkCode=df0&hvadid=167146070393&hvpos=&hvnetw=g&hvrand=15294800680040780 20&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1021085&hvtargid=pla-273753422291&psc=1
- 1/8” x 12” wooden dowel rod (not pictured): https://www.amazon.com/Wood-Dowel-Rod-Inches-Pieces/dp/B091JWFC3J/ref=sr_1_1?crid=1XLIUA0TEE0L9&keywords=dowel+rod+1%2F8+inch&qid=1657333546&refinements=p_85%3A2470955011%2Cp_36%3A2638326011&rnid=2638325011&rps=1&s=arts-crafts&sprefix=dowel+rod+1%2F8+inch

Figure 1: Supplies

Step 1: Cervical Spine Model Modifications

There are four modifications that need to be made to the cervical spine model for successful use under fluoroscopic guidance as a C1-C2 model. First, the artery and spinal cord portions of the model can be easily removed by hand. Next, the metal supporting rod must be removed. The bottom of the metal rod is secured with a washer (see Figure 2), which can be easily removed with pliers; however, the rod is also secured internally with adhesive. Therefore, it is best to soak the model in goof off to help loosen this adhesive. Third, there are two screws located medially on the occipital bone (Figure 3). These muse also be removed in order to increase spacing between the atlas and axis bones so that the C1-C2 puncture can be performed. Once these screws are removed, atlas and axis bones must again be soaked in goof off to removed adhesive keeping the two bones together. Ideally, these bones will be soaked separate from the rest of the model due to erosive potential of the goof off. In order to separate the bones from the rest of the model, the two larger lateral screws can be temporarily removed as well for soaking purposes. Once the atlas and axis bones can be separated, one should re-glue these two parts back together, using a thicker layer of glue (gorilla glue, E6000, or other adhesive gel can be used) in order to create more space between the bones for more realistic C1-C2 spacing (about 2mm). Figure 4 shows comparison between the original model and the model with additional space created in the atlantoaxial joint. Finally, the model can be put back together using a wooden dowl rod instead of the metal rod that was removed and gorilla glue to secure the vertebrae and discs together (Figure 5). The lateral screws removed for soaking can be put back on to secure the occipital bone to the spine.

Figure 2: Washer securing metal rod. The red artery and yellow spinal cord portions can be removed by hand.

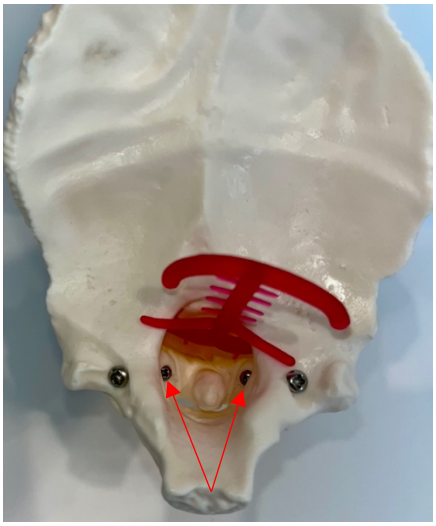


Figure 3: Medial screws that must be removed to create more space between atlas and axis bones.

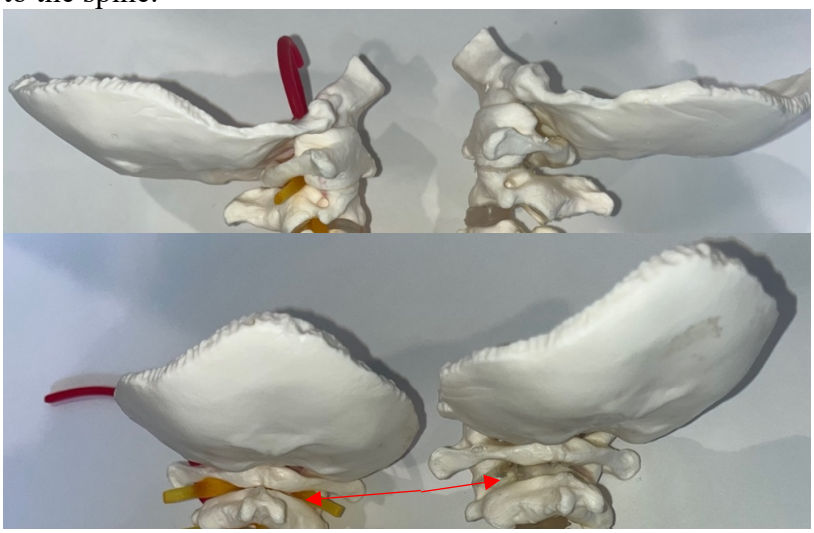


Figure 4: Difference in atlantoaxial joint space after addition of adhesive layer as described above. Before is left, after is right.

Figure 5: Dowel rod and gorilla glue used to secure model after metal rod has been removed. It is helpful to number the vertebrae and discs, so you put the spine back together in the correct order.

Figure 6: Latex tubing pulled through the spinal canal on the cervical spine model.

Step 2: Addition of latex tubing

Next, the latex tubing (1/2" ID, 5/8" OD), will be pulled through the spinal canal, where the yellow spinal cord replicas were removed. This can be difficult to gain enough traction to pull the tubing through the canal, so a forceps or hemostat can be used to pull the tubing through the canal (Figure 6). Alternatively, this step can be accomplished during step 1, when the vertebrae and discs are being joined back together with the wooden dowel rod. Make sure to pull the tubing through far enough so that the length of the latex balloon spans from the very bottom of the latex tubing up past the cervical model. This will be important for Step 4: Addition of inner latex balloon. Next, the valve adapter should be screwed into the PVC on/off valve, so that it can be attached to the latex tubing on one side.

Finally, the adapter/PVC on/off valve can be attached to the tubing (Figure 8).

Figure 7: Valve adapter attached to PVC on/off valve

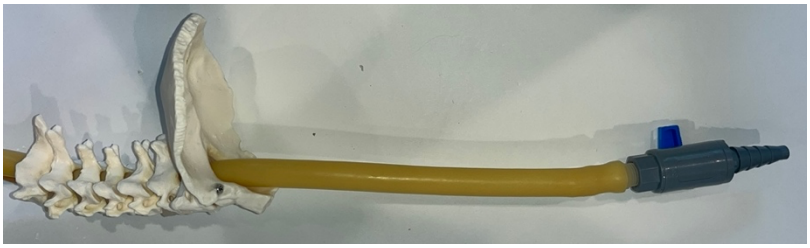


Figure 8: Attaching the PVC of/off valve to the latex tubing

Step 3: Creating neck tissue replica using alginate molding

In this step, we will be using the cut soda bottle, which will contain the cervical spine and tubing, to create a neck replica using the alginate molding. The “neck” mold was created by cutting a cylindrical 2-liter bottle approximately in half (about the height of the cervical spine model). Then, a round hole was cut in the center of the bottom of the bottle to allow the tubing to pass through. In our model, the edges of the hole for the tubing were jagged, so we taped duct tape around the edges to prevent it from damaging the tubing (Figure 9). Next, the cervical spine model with latex tubing is placed into the cut 2-liter, with the inferior end of tubing fed through the hole at the bottom of the 2-liter. Now, the inferior end of the tubing should be clamped off/sealed with forceps or a hemostat, and the tubing should be filled with water using the syringe and PVC on/off valve (Figure 10). By filling the tubing with water, it will prevent collapse of the tubing when the mold is filled with alginate. Now, it is time to add the alginate molding to the model. Follow the

Figure 9: bottom hole of neck mold made from 2L bottle, with duct tape to protect tubing from jagged edges.

directions on the alginate mold you are using for your model. For the Luna Bean brand alginate mold, we used 1 cup cold water per 60g alginate. In total, we used about 270g alginate and 4.5 cups water to enclose the cervical spine. In order to have enough time to pour the mold, we used refrigerated temperature water. Once the alginate and water are mixed, pour the liquid into the mold you created (Figure 11).

Figure 10: Neck mold containing cervical spine model and tubing filled with water and occluded with a hemostat.

Figure 11: Filling the mold with the alginate mixture. Note, this step can get a little messy!

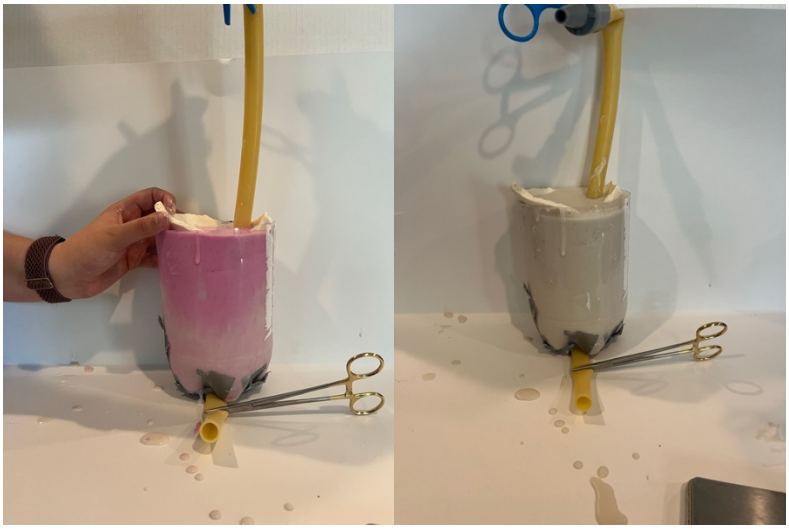


Figure 12: Before (pink) and after (gray) setting alginate mold

It is helpful to have an extra set of hands for this step to secure and stabilize the cervical spine in the center of the mold while pouring. The mold is set when it changes from pink to light gray in color (Figure 12). After the mold has set, you can remove the hemostat clamping the latex tubing on the bottom and drain the tubing. With some minor wiggling and shaking, you should now be able to slide the model out of the plastic neck mold. (Figure 13).

Figure 13: Alginate model removed from mold

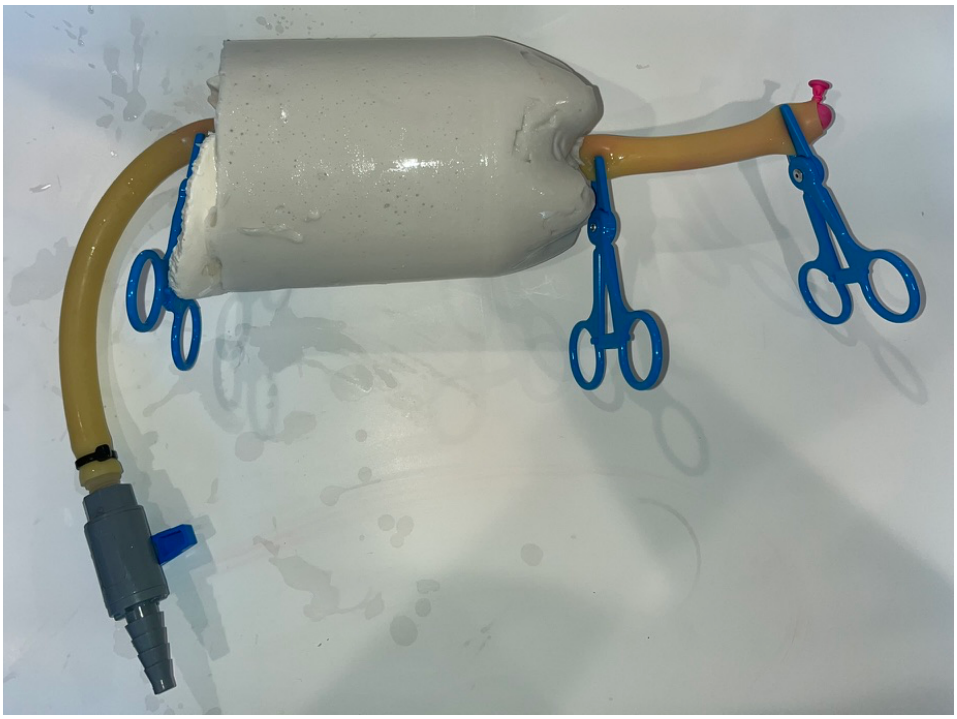
Step 4: Addition of inner latex balloon

Now, you will be threading the inner latex balloon into the latex tubing. This balloon will represent the spinal cord and will be filled with dyed liquid so that if it is pierced with the spinal needle, dyed liquid will return. In order to thread the balloon in the tubing through the canal, you will need a stiff filament. In this tutorial, we cut the long end of a metal clothes hanger. Anatomically, the spinal cord lies more anteriorly in the cervical spinal canal, so it is best to partially occlude the posterior half of the latex tubing superior and inferior to the alginate model so that when you feed the balloon through the tubing, it lies more anteriorly (see Figure 14). Feed the balloon onto the metal filament and inset both through the latex tubing from the caudal end to the cranial end. It's helpful to use a bright colored balloon, because you can vaguely see the balloon on the cranial end once it is threaded so it's easier to tell that it has been threaded completely. Once you see the balloon has made it past the alginate model, pinch the tubing at the end of the balloon with your fingers, making sure that you are only pinching the tubing and the end of the balloon, not the metal rod. Slowly slide the metal rod out from the model, making sure to hold the balloon in place by continuing to pinch the end. After successfully removing the metal rod while keeping the balloon in position, you are now ready to add dyed liquid to the balloon. Keep the superior and inferior clamps seen in figure 14 in place in order to ensure anterior placement of the spinal cord. Use liquid food coloring to dye the liquid that will fill the balloon, making sure to be liberal with the dye (we used 4-6 drops for about 300mL water). The more pigmented this liquid is, the easier it'll be to tell if the "spinal cord" is punctured when using the model. Use the syringe to fill the latex balloon with the dyed liquid (Figure 15). You will be able to tell there's enough liquid in the balloon when you notice the end starting to bulge. When it is sufficiently filled, tie off the end of the balloon with a knot, making sure not to pull the balloon out too much so that it remains in place. Using a third clamp or hemostat, clamp off the bottom of the latex tubing and balloon. Refill the latex tubing with clear/non-dyed water using the syringe and PVC on/off valve. Close the PVC on/off valve when the latex tubing is completely refilled with water.

Figure 14: Latex balloon fed through latex tubing. Note the balloon with metal rod fed through at the bottom of the image. Two clamps are placed above and below the alginate model on the posterior half of the tubing to ensure anterior placement of the balloon, which represents the spinal cord.

Figure 15: Using a syringe to fill the pink inner latex balloon with dark red dyed liquid

Congratulations! Your model is now complete, and you are ready to use the model to practice C1-C2 punctures under fluoroscopic guidance. For an added challenge, you can cover the tubing above and below the alginate model (with a towel for example), so that students using the model have to solely rely on fluoroscopy to determine spinal needle placement.



Completed model. Here the inner latex balloon is in the anterior portion of the tubing and filled with red dyed water. The latex tubing is filled with clear water. Clamps proximal to the alginate model secure the balloon in the anterior position. The distal clamp seals the outer latex tubing, and the PVC valve is in the off position. You may notice the latex tubing is secured with a zip tie to the PVC valve. This is not necessary, and was just done to help ensure a better seal so more water can been added to the tubing to create some additional pressure