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Special Article

The Endovascular Training Model for Continuing Medical Education Courses

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Abstract: *Today's CME programs are mainly in lecture format and lack the hands-on learning experience that is so important in acquiring the skills connected with current technologic innovations. To fill this void, we have developed the life-size Endovascular Training Model, which can be used to practice various endovascular procedures. The model has been used in two CME courses with positive results. We present this model as a useful educational tool in vascular surgery CME courses.*

Key Words: endovascular, training model, continuing medical education, hands-on learning

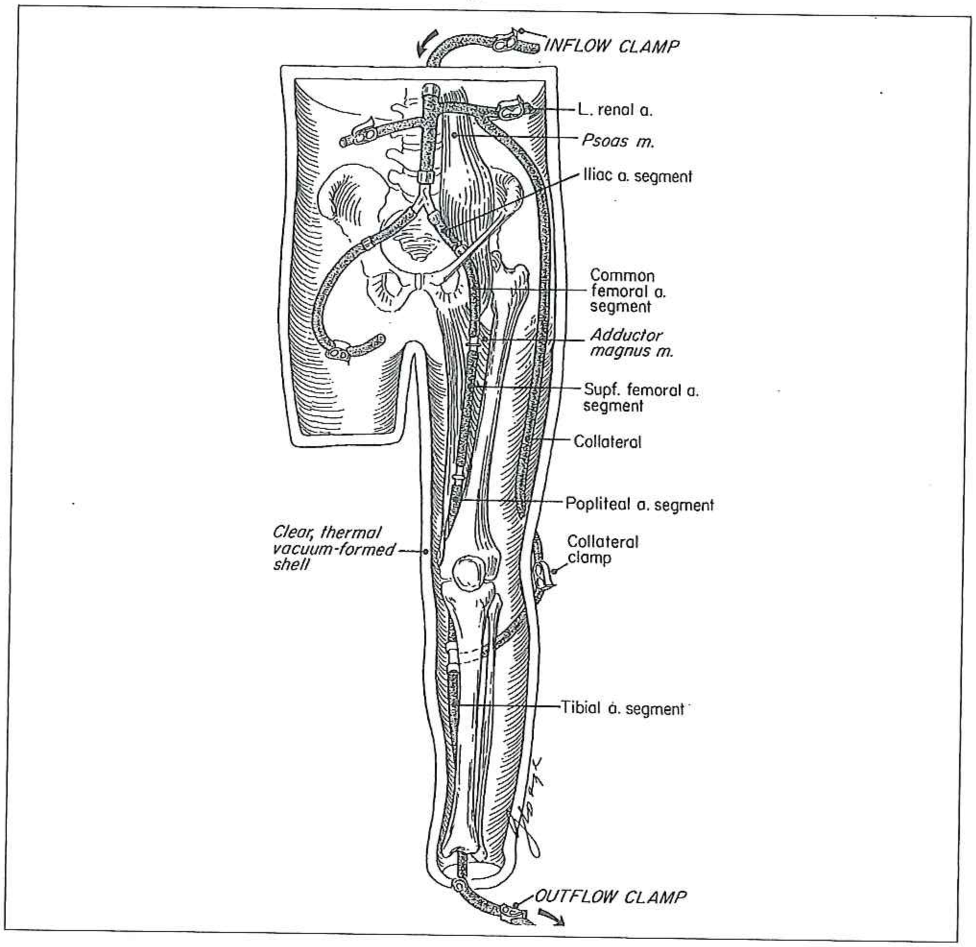
Background

Many continuing medical education programs utilize a didactic lecture form to provide information on current advances in the medical field. However, in order to acquire the technical skills needed to use the innovations in practice, participants need hands-on learning experience.

Vascular surgeons have available to them many CME programs, particularly since the recent explosion of new technical endovascular procedures. Most of the time, the bulk of information is presented in traditional lecture form, with little or no exposure to hands-on experience. Limiting factors for hands-on learning are that it requires the use of either animals or models. Not only is using animals expensive and wasteful, but their use for educational and research purposes can generate protests from community animal rights advocates. Most of the problems connected with animal use can be obviated if suitable models can be found.

At present, there are few models available that can accurately simulate a particular function or structure of the human body. A good vascular model should be life size and should display normal arterial anatomy, abnormal

Figure 1

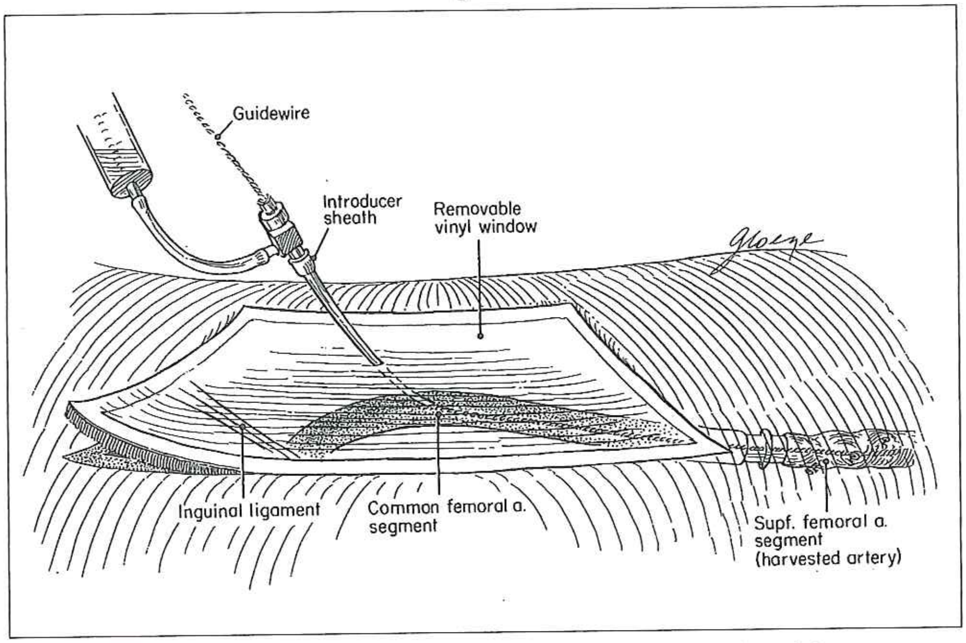


vessel pathology, and circulatory hemodynamics. We report here the Endovascular Training Model, which fulfills these criteria, and is easy to use, inexpensive to maintain, and capable of functioning as an educational tool in vascular surgery CME courses.

Materials and Methods

The model (see Figure 1) is a life size figure of a human body extending from the xyphoid process to the left ankle. The vascular system is encased in a clear, thermal vacuum-formed shell in the shape of the human body. This allows the vascular system to be easily visualized, either by looking through the transparent top or by displacing the rubber bolts and removing the top. The shell also contains a life-like, anatomically correct bony structure skeleton made of pigmented white, rigid urethane foam. Attached to the skeleton

Figure 2

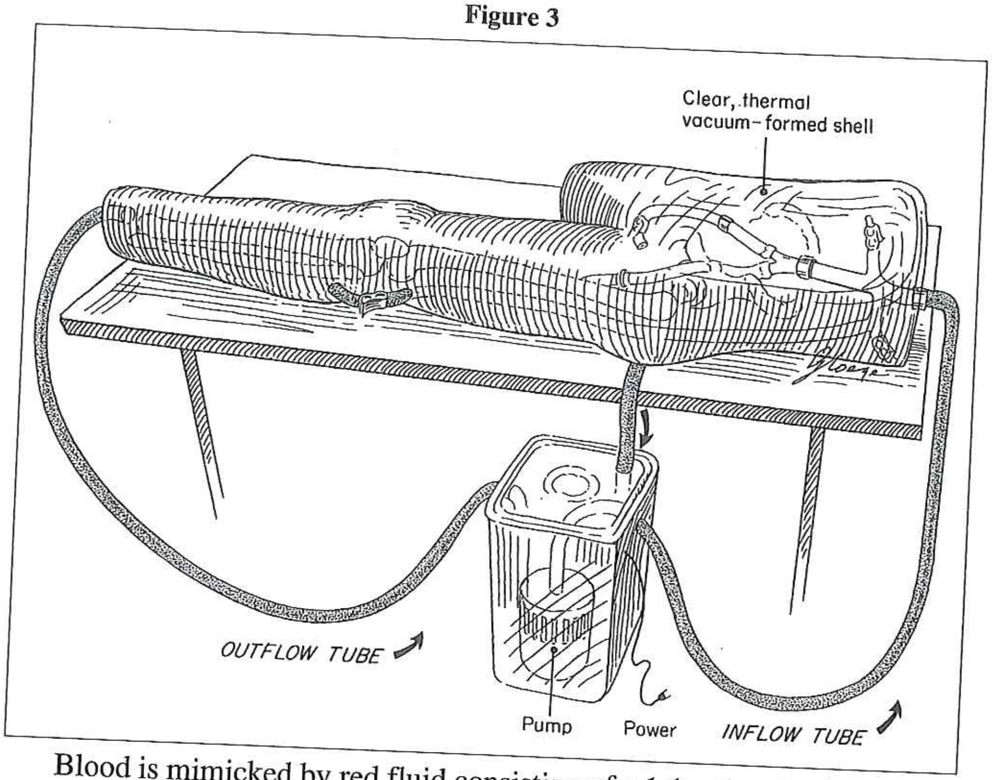


is a red strip of neoprene rubber material that represents the adductor magnus muscle extending from the ischial tuberosity to the left distal femur to form the adductor canal.

The vascular tree consists of clear vinyl tubing, except that the common femoral artery is made of opaque latex rubber tubing. This system is held in place by a few plastic securers located on the skeleton. The system begins at the proximal end with 1.5 cm vinyl tubing (representing the aorta) and two .75 cm tubes (the renal arteries). The 1.5 cm tubing continues down to a Y connector (the aorta bifurcation) dividing into two tubes of 1.25 cm each (the iliac arteries). The tube on the right side curls downward and is clamped closed. The tube on the left (representing the left iliac artery) continues through the left pelvis and attaches to the opaque rubber tubing (the external iliac artery) via a polyethylene plastic connector. This segment of tubing courses through a simulated femoral canal, becoming the simulated femoral artery. A subsequent connector attaches to still another tube (the superficial femoral artery). From there the tube continues through the adductor canal (representing the popliteal artery) and finally to the below-the-knee area.

Another feature of the model is an extra tubing that courses from the renal artery to the popliteal artery. This collateral channel is important so that when the femoral or iliac artery is clamped or occluded, there will be sufficient "backbleeding" from the popliteal artery.

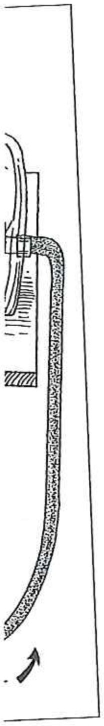
Figure 3



Blood is mimicked by red fluid consisting of a 1:1 ratio of red food coloring and a 12-ounce can of tomato juice in two to three gallons of water. A recirculation pump immersed in a bucket reservoir below the model forces the fluid through the circulation (Figure 2). The inflow tube feeds into the aorta while one outflow tube disperses distally through the left ankle and then courses back to the bucket reservoir, thereby completing the closed recirculation system. Another outflow tube connects to a drainage hole and courses to the reservoir at the bottom of the right pelvis to drain any fluid spilled inside the thermoform plastic shell. The system is now complete and can be activated by plugging the cord of the pump into a standard electrical outlet.

The circulatory flow of the model is controlled by the use of Roberts clamps. The inflow tubing is usually kept open, while the clamp on the collateral is kept partially closed so that most of the flow will go through the main aorta. Also, the outflow clamp at the ankle can be kept partially shut, thereby increasing resistance within the system and simulating normal arterial pressure.

A unique feature of this system is the ability to insert harvested human cadaver arteries anywhere along the vascular tree (Figure 3). For instance, it



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is possible to insert a piece of harvested human superficial femoral artery into the appropriate position in the model. The artery is held in place by two plastic, polyethylene connectors that are quick-fitted to plastic tubing that can then be cut to any length. We have successfully harvested many human arteries which, when introduced into the model, have offered the CME participant an assortment of pathological states.

We have also succeeded in making artifical arteries with simulated pathology, using a slurry of chalk, lard, and molasses that is poured into a vinyl tube. To produce concentric lesions we rotate the tube so that the mixture disperses and gradually hardens evenly. To make eccentric lesions we allow the slurry to harden by rotating the tube minimally.

Another feature is a window located in the femoral artery position. It is made of clear, pliable vinyl of 3 mm thickness that is interchangeable and can be used and punctured as many times as desired (Figure 2). That the vinyl closely resembles human skin is demonstrated by the fact that an introducer dilator cannot be inserted unless the vinyl is first cut with a number 11 blade. The window allows for the performance of percutaneous procedures; it also permits open procedures by removing it so as to gain direct access to the femoral artery.

A number of standard endovascular procedures can be performed—either percutaneously or openly—once there is access to the femoral artery. It is possible to visualize a lesion, either with an angioscope or an angiogram. One can insert a balloon catheter over a guidewire for angioplasty. A Simpson atherocath or a rotary atherocath can be inserted through the sheath to perform atherectomy of a simulated arterial model or a harvested cadaver artery. It is also possible to perform laser-assisted balloon angioplasty or to insert stents. Once a procedure is completed, the sheath can be removed with minimal leakage through the simulated femoral artery.

Results

The Endovascular Training Model has been utilized in two vascular surgery CME courses offered through UCLA. Endovascular techniques such as angiography, angioscopy, atherectomy, balloon angioplasty, laser angioplasty, and the placement of stents were demonstrated. In each course, more than 300 participants used the model to perform hands-on procedures. Greater than 80 percent of the participants reported that their experience in the laboratory section with the model was both pertinent and valuable.

A common difficulty encountered and reported by participants was in threading the guidewires and catheters through the latex tubing and then through the plastic connector to reach the diseased artery. This problem can be attributed to the design of the plastic connectors which inhibited a smooth passage within the artery. It is worth noting that these obstacles closely mimic the diffusely diseased arteries found in human patients.

Discussion

We found the Endovascular Training Model to be a successful educational apparatus in vascular surgery CME courses. It is easy to use and sufficiently simulates the human vascular system that participants are able to attempt many of the endovascular procedures themselves in a short amount of time. Because the model is reusable, there is minimal waste. The model is economical: maintenance costs are minimal, leaving the initial purchase cost as the principal consideration.

The model has not been free of technical problems. The initial CME courses showed that the edges and lips of the polyethylene connectors need to be smoother so that guidewires and catheters can more easily reach their destinations. The red fluid needs to be improved: the red food coloring was added simply to color the fluid, while the tomato juice was added to make the fluid opaque so as better to simulate blood. Because of its organic nature, the fluid tends to decay and needs to be flushed out daily. The tomato juice also requires special care since it can stain clothing.

As to the artifical arteries, while they successfully simulate calcified totally occluded arteries, they were unable to mimic softer, fibrous lesions or stenosis. Moreover, the artificial arteries worked well in demonstrating atherectomy, but were not easily penetrated by lasers in laser-assisted balloon angioplasty procedures. We are presently studying ways of producing more realistic soft lesions and stenosis.

We believe that this model will permit the development of many innovative improvements and extensions. It should not be too difficult to design a model simulating the vascular tree in the area above the xiphoid process. Also, it may prove feasible to improve the simulated tissue surrounding the artery to more closely resemble the human soft tissue around an artery that is undergoing balloon angioplasty.

While the Endovascular Training Model has many indisputably useful characteristics, it is still only a replica of the human body and vascular tree. Nonetheless, for the purposes of hands-on training in endovascular surgery CME courses, the Endovascular Training Model provides an inexpensive and effective means to meet the need of physicians seeking to incorporate endovascular procedures into their practices. We offer this model as a guide and as a stimulus to other investigators to design models in their respective fields.

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