

Teaching Pediatric Procedures: The Vancouver Model for Instructing Seldinger's Technique of Central Venous Access Via the Femoral Vein

ABSTRACT. The way in which physicians are trained to do invasive practical procedures is an ongoing challenge for educators. Percutaneous insertion of a central line via the femoral vein using the Seldinger technique is an important practical pediatric procedure, and the need for physicians to be educated in the necessary skills is recognized in current training initiatives such as Pediatric Advanced Life Support (PALS) and Advanced Pediatric Life Support. Unfortunately, the majority of instruction in central venous access techniques is theoretic. This approach does not provide the hands-on training needed to give practitioners the necessary practical experience, or confidence in their skills.

Practice using simulated tissue can enable physicians to perform practical skills with greater confidence. However, although commercially available models exist for peripheral venous access, a recent cross-Canada survey of the 13 PALS program coordinators and a similar inquiry to the American Heart Association indicated that none of them had a pediatric practice model for central venous access.

We describe 1) how to construct from materials readily available a pediatric model for the insertion of central venous catheters into the femoral vein using the Seldinger technique, and 2) an evaluation of the change in confidence learning with the model engendered. In our experience, this model is inexpensive (less than \$50) and can be replicated readily by others for use as a teaching aid. It provides inexperienced physicians the opportunity to learn the practical elements of the technique and acquire confidence in the Seldinger method. Our hypothesis was that the confidence and skill of physicians would be increased by practical experience of central line insertion using a realistic model.

The model enables trainees to be taught the technique described in the PALS manual to locate the femoral artery. They then can learn to introduce a thin-walled needle or over-the-needle catheter, one finger's breadth below the inguinal ligament and just medial to the location of the femoral artery. The needle or over-the-needle catheter then can be advanced at the correct angle if the needle is directed toward the model's umbilicus. As occurs in vivo, the model allows for a free flow of fluid to be obtained as the "vessel" is entered. If the Foley catheter simulating the vessel is transfixed, negative pressure applied as the needle is withdrawn will result in fluid being obtained as the needle tip reenters the "vessel."

The syringe then can be removed from the needle, and the key elements of the procedure—correct insertion of the Seldinger guide wire and passage of the venous catheter over the guide wire into the vessel—can be practiced. If desired, instruction also can be given on the use of a dilator and techniques of taping the catheter in place and all the appropriate techniques to avoid potential air embolism. However, the model does not lend itself to instruction in suturing.

The model has been used to teach the practical elements of this technique to 428 physicians (emergency physicians, 49%; pediatricians, 24%; other physicians, 20%; pediatric residents, 7%). Their success rate for cannula insertion in three or fewer attempts was 87%. The last 218 physicians were evaluated to assess the influence of learning with the model on their confidence to perform the technique successfully in an emergency. Before training they were asked, "Have you done a pediatric resuscitation course that taught this technique in theory?" and "Rate your confidence level for performing central vascular access in a patient from 0 to 5 (none, very little, some, moderate, good, complete)." This rating was repeated after the training session using the model. For 154 (71%) answering "yes" to a previous resuscitation course, mean scores were 1.52 (standard error [SE] \pm 0.91) after theoretic instruction and 4.06 (SE \pm 0.47) after practical education using our model. The 64 (29%) physicians taught using the model only rated their mean confidence level at 1.48 (SE \pm 0.7) before training and 4.00 (SE \pm 0.35) after training. There was no significant difference in before and after scores between groups. The overall means ($n = 218$) of 1.51 (SE \pm 0.85) before training and 4.04 (SE \pm 0.44) after training indicate a significant change in confidence after practical experience performing the procedure using the model. Consequently, it appears that our model is a constructive teaching aid that would be appropriate for PALS, Advanced Pediatric Life Support, and equivalent continuing medical education courses that currently teach this element of pediatric resuscitation only as procedural theory.

This model, like any other, has inherent limitations. Careful construction is necessary to ensure anatomic correctness so that the landmarks can be identified appropriately, the depth of the catheter simulating the femoral vein is realistic, and its direction below the inguinal ligament is correct. We suggest that simple models such as the one described that simulate tissue can add important educational elements to the instruction of pediatric practical procedures. *Pediatrics* 1999;103(1). URL: <http://www.pediatrics.org/cgi/content/full/103/1/e8>; *vascular access, resuscitation, pediatric, education, PALS/APLS*.

ABBREVIATIONS. PALS, Pediatric Advanced Life Support; IV, intravenous.

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The Vancouver Central Venous Access Model was developed by British Columbia's Children's Hospital, Division of Critical Care.

The Paramedic Academy at the Justice Institute of British Columbia is responsible for coordinating Pediatric Advanced Life Support training in the province of British Columbia.

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The way in which physicians are trained to do invasive practical procedures is an ongoing challenge for educators. Reliable vascular access is a key component of pediatric critical care and

a crucial step in pediatric resuscitation.¹ It is essential for the infusion of fluids in cardiovascular compromise secondary to trauma or sepsis.² In many children, peripheral venous access either does not provide adequate flow rates or is difficult to achieve because of vessel size. In these situations, cannulation of a larger, central vein is the procedure of choice, but must be performed with caution because complications are more common in the pediatric age group.³⁻⁵ The incidence of complications depends on the site of vascular access, the clinical condition of the patient, and the experience of the clinician.^{6,7} Percutaneous insertion of a central line via the femoral vein using the Seldinger technique is an important practical pediatric procedure, and the need for physicians to be educated in the necessary skills is recognized in current training initiatives such as Pediatric Advanced Life Support (PALS) and Advanced Pediatric Life Support. Unfortunately, most instruction in central venous access techniques is theoretic, and courses usually are unable to provide realistic opportunities for actual practice insertion. This approach does not provide the hands-on training needed to give practitioners confidence in their skills or the practical experience implied in the PALS manual. The manual states that cannulation of a central vein "should be performed or directly supervised by an experienced clinician who is knowledgeable about the unique features of central venous anatomy in infants and children."⁶

Commercially available models exist for peripheral venous access. However, a recent cross-Canada survey of the 13 PALS program coordinators and a similar inquiry to the American Heart Association indicated that none of them had a pediatric practice model for central venous access available.

Our hypothesis was that the confidence and skill of physicians would be increased by practical experience of central line insertion in a realistic model. We developed a pediatric model for the insertion of central venous catheters into the femoral vein using the Seldinger technique.⁸ In our experience, this model is inexpensive (less than \$50) and can be replicated readily. It provides inexperienced operators the opportunity to learn the practical elements of the technique and develop confidence in the Seldinger method.

Construction of the Model

The model is shown in Figs 1 and 2. The primary structure representing the pelvis and upper thighs is constructed using empty 500 mL plastic bottles (eg, sodium chloride irrigation, Baxter Corporation, Toronto, Canada). These bottles are square, which provides stability, and their size results in a model that approximates the pelvic size of an 8-year-old child.

Two bottles, representing the thighs, are placed in alignment on a flat surface, and a third bottle, representing the abdomen and pubis, is placed between them. The bottles are fastened together with duct tape. With practice, the bottles representing the thighs can be everted slightly to give a normal position for the "limbs."

A latex Foley catheter (14 g) is threaded across the

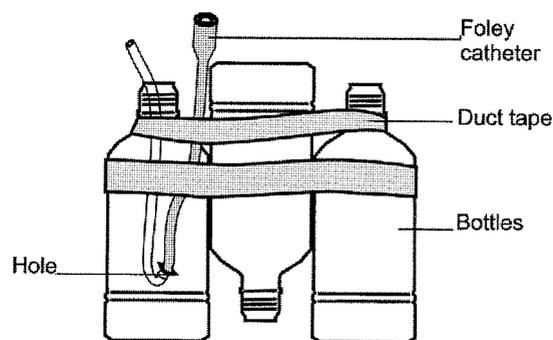


Fig 1. Basic structure of the Vancouver Central Venous Access Model.

bottle representing the right thigh and is inserted through a hole punctured in the bottle wall (Fig 1). The tip of the catheter is retrieved through the neck of the bottle and the catheter tip knotted or occluded with artery forceps so that it will retain fluid within its lumen.

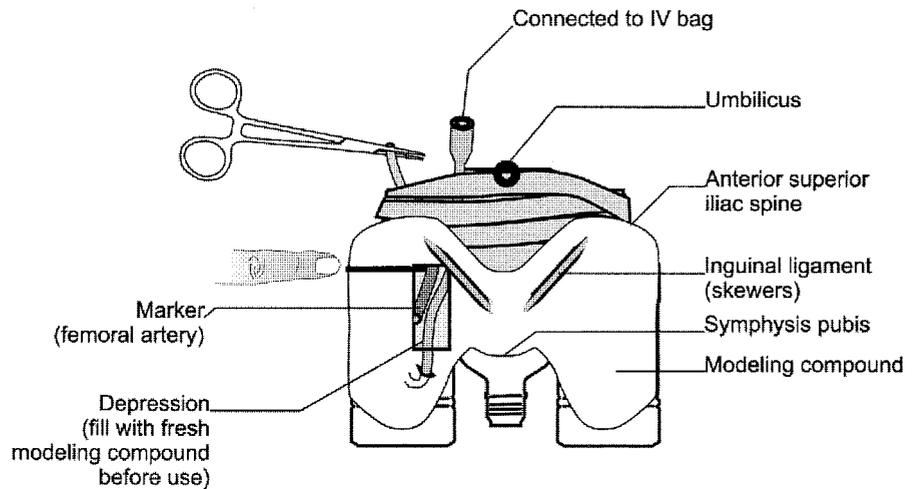
"Tissue" is built up on the framework of bottles using a modeling compound such as DAS Pronto (Battat Inc, Adica Pongo Division, Plattsburgh, NY). This soft compound is molded to simulate the symphysis pubis and the musculature of the thighs. The shoulder of the "thigh" bottles are positioned to represent the anterior superior iliac spines, and the symphysis pubis and umbilicus are identified in the midline over the "abdomen" bottle in the anatomically correct location.

The inguinal ligament needs to be identifiable between the symphysis pubis and the anterior iliac spine. This can be simulated using material such as a wooden skewer or chopstick wrapped with duct tape. This allows the ligament to be identified by its gray color and avoids contamination of the landmark by the modeling compound.

The Foley catheter representing the femoral vein is placed in the anatomically correct position between the entry hole in the bottle and the point at which it passes below the landmark of the inguinal ligament. The latter point should be just medial to the middle of a line drawn between the symphysis pubis and the anterior superior iliac spine (Fig 2). The catheter is connected to an intravenous (IV) bag of normal saline to which 0.5 mL of red food coloring has been added to simulate blood, and should be filled with fluid before the tip is knotted or clamped. Pressure is maintained within the IV bag by means of either a pressure cuff or a heavy weight pressing on the bag (eg, a brick or textbook). This allows "blood" return when the percutaneous needle punctures the catheter.

As the DAS compound is built up, a depression ~1.5 cm wide and 4 cm long is left around the intended site of vascular access, immediately inferior to the inguinal ligament (Fig 2). This depression is left because the DAS modeling compound hardens over a few hours when in contact with air. For realistic simulation of percutaneous needle insertion, fresh modeling compound is added just before using the model and is removed when the session is finished. An alternative is to fill the depression with material such as Play-Doh (Parker Bros, Concord,

Fig 2. Complete model with anatomic landmarks.



Ontario, Canada), which remains soft. However, this results in a color discrepancy in the model that can make the simulation less realistic. A drape is placed over the superior aspect of the model, covering the egress of the catheter and the connection to the IV bag.

Trainees can be taught the technique described in the PALS manual⁶ to locate the femoral artery below the midpoint between the anterior superior iliac spine and the symphysis pubis. They then can learn to introduce the thin-walled needle or over-the-needle catheter through the skin, one finger's breadth below the inguinal ligament and just medial to the location of the femoral artery. If there are concerns about the anatomic accuracy of the model or the skill level of those learning the technique for the first time, the location of the femoral artery can be simulated with a marker (eg, a 2-cm segment of chopstick wrapped with red insulating tape). This marker is placed in the modeling compound to extend from the inguinal ligament 2 cm inferior and immediately lateral to the catheter simulating the femoral vein.

Once the needle or over-the-needle catheter has been introduced through the skin, it can be advanced at a 45° angle with the needle directed toward the model's umbilicus. As in vivo, a free flow of fluid is obtained as the vessel is entered when negative pressure is applied to the syringe. If the vessel is transfixied, negative pressure applied as the needle is withdrawn will result in fluid being obtained as the needle tip reenters the "vessel." The syringe then can be removed from the needle, and the key element of this important practical procedure—correct insertion of the Seldinger guide wire—can be taught.⁶ All the appropriate techniques to avoid potential air embolism also can be learned, as can the correct moment to advance the guide wire (during a positive pressure breath or spontaneous exhalation). After the needle is removed, trainees can practice passing the venous catheter over the guide wire into the vessel. If desired, instruction also can be given on the use of a dilator and techniques of taping the catheter in place. However, the model does not lend itself to instruction in suturing.

Practical Experience Using the Model

The model has been used to teach the practical elements of this technique to 428 individuals (emergency physicians, 49%; pediatricians, 24%; other physicians, 20%; pediatric residents, 7%). Their success rate for cannula insertion in three or fewer attempts was 87%. The 210 emergency physicians evaluated the continuing medical education workshop where they used the model as a specific item in an overall course evaluation. Mean scores were 4 to 6 (range, 0 to 5, poor to outstanding), and written comments stressed the educational value of being able to actually perform the procedure and that this practical experience increased confidence in achieving successful access in an emergency.

The other physicians ($n = 218$) were evaluated to assess the influence of learning with the model on their confidence to perform the technique successfully in an emergency (Table 1). They were asked, "Have you done a pediatric resuscitation course which taught this technique in theory?" and "Rate your confidence level for performing central vascular access in a patient from 0–5 (none, very little, some, moderate, good, complete)." This rating was repeated after the training session using the model. For 154 (71%) trainees answering yes to a previous resuscitation course, mean scores were 1.52 (SE \pm 0.91) after theoretic instruction and 4.06 (SE \pm 0.47) after practical education. The 64 physicians (29%) taught with the model only rated their mean confidence level at 1.48 (SE \pm 0.7) before and 4.00 (SE \pm 0.35) after training. There was no significant difference between before and after scores between groups. The overall means ($n = 218$) of 1.51 (SE \pm 0.85) before and

TABLE 1. Evaluation of Change in Confidence to Perform Central Vascular Access After Receiving Practical Instruction Using a Model

Resuscitation course with vascular access theory ($n = 218$)	Yes ($n = 154$)	No ($n = 64$)
Mean confidence level after theoretic instruction (range, 0–5)	1.52 (\pm 0.91)	1.48 (\pm 0.7)
Mean confidence level after practical education (range, 0–5)	*4.06 (\pm 0.47)	*4.0 (\pm 0.35)

* $P < .0001$.

4.04 (SE \pm 0.44) after training (F test $P < 0.0001$) indicate a significant change in confidence after practical experience using the model. Consequently, it appears that the model is a constructive teaching aid that would be appropriate for PALS, Advanced Pediatric Life Support, and equivalent continuing medical education courses that currently only teach this vital element of pediatric resuscitation as procedural theory.

Modeling material sometime is aspirated into the needle used for percutaneous location of the vessel, obstructing return of fluid so that the operator fails to recognize that the vessel has been accessed. The needle can be cleared readily by expelling some of the fluid from the syringe. Because needle blockage is encountered in vivo, this situation is not without value.

The useful life of the percutaneous needles, wires, and catheters tends to be limited, and this represents a cost element in the teaching process. In our experience with teaching pediatricians and pediatric residents, the sets (Cook single lumen 3.0 French central venous catheter, Cook Inc, Bloomington IN) last for five to eight insertions. When training adult emergency physicians, needles tend to become blunted and wires kinked more often.

DISCUSSION

The femoral vein is the vessel used most frequently during emergency central venous cannulation in the child because of its consistent anatomy, relative ease of access, and lower rate of complication.⁷ The Seldinger technique provides a reliable method of access in a variety of situations including acute emergencies⁶; however, like most resuscitation procedures, the chances of success with this technique increase when theoretic knowledge is complemented with actual practice. This model is simple to construct, inexpensive, and allows comprehensive instruction of access via the femoral vein, including practical insertion experience that current training courses lack. The use of simulated tissue enables physicians to act more expertly and with greater confidence.⁹

This model, like any other, has inherent limitations. Care is necessary in construction to ensure anatomic correctness so that the landmarks can be identified appropriately, the depth of the catheter simulating the femoral vein is realistic, and its direction below the inguinal ligament is correct. The model can be constructed to approximate children of

different ages, but the catheter used to simulate the femoral vein must be of appropriate size. It is likely that other modeling compounds (eg, Plasticine) could be used effectively and that a more sophisticated model could be developed with a latex covering to simulate skin more readily. We suggest that this simple model can add important educational elements to the instruction of pediatric central venous access.

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