Temporary Vascular Shunting

Mark Bowyer, Christopher Gross

Introduction

Temporary vascular shunting is a surgical procedure used to rapidly restore blood flow to an area of the body when there is an injury or obstruction in a blood vessel. This technique involves inserting a temporary conduit, called a shunt, into the blood vessel to bypass the damaged or blocked segment. The shunt maintains perfusion to the tissues downstream of the injury, preventing ischemia (lack of blood flow) and potential tissue damage.

This procedure is often used in emergency settings, such as during trauma surgery, to stabilize the patient and buy time until a more permanent vascular repair can be performed. Temporary shunting can be critical in saving limbs and organs by ensuring continuous blood supply during the initial stages of treatment.

Temporary vascular shunting is a damage control technique that should be considered in patients who:

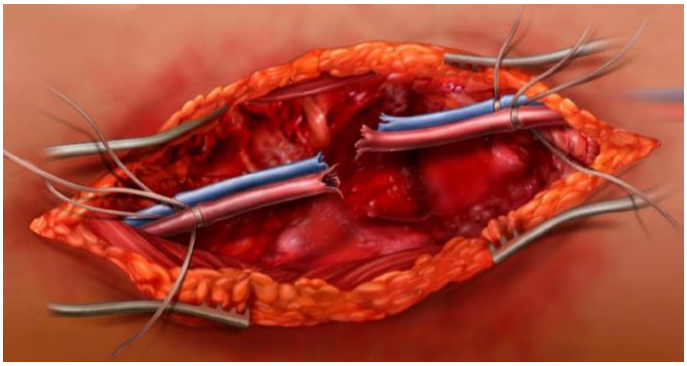
- Have the lethal trauma triad (acidosis, hypothermia, and coagulopathy) and need time for stabilization in the ICU prior to definitive repair
- Need initial orthopedic injury repair prior to definitive vascular repair
- Need to be temporized before transferring to a higher level of care with necessary expertise and resources to perform definitive repair
- Are involved in mass or multiple casualties with limited resources on hand.

This chapter will focus on principles for temporary vascular shunt placement. In general, the surgical principles are as follows:

- Gain vessel exposure
- Gain proximal and distal control of transected artery
- Dilate and clear any clots by inserting Fogarty catheter proximally and distally
- Identify and prepare shunt to fit snugly into vessel
- Trim shunt to extend about 1.5-2cm on either side of defect
- Place 2-0 silk suture in the shunt center
- Place and secure shunt with 2-0 silk ties
- Shunt both the artery and vein when possible
- Confirm distal flow with Doppler ultrasound or palpation

Steps:

1. Consider typical preoperative factors to prepare for operation (overall health, hemodynamic stability, assess vascular injury extent and distal tissue viability).
2. General anesthesia is typically preferred, but regional anesthesia can be used under certain circumstances.
3. Position, prepare and drape, and incise to provide optimal access to the injured vessel. Individual vascular exposures are described in separate chapters of this Manual.
4. Dissect down to gain adequate exposure of the target vessel.
5. After identifying the injured vessel, obtain proximal and distal control. Use vessel loops, which are elastic bands that occlude a vessel without causing damage when wrapped twice around the vessel (Pott's technique). An alternative in resource-limited settings is the rolled cuff of a sterile glove, or a sterilized rubber band. Vascular clamps, if used, should not be clamped tightly. Ordinary clamps such as hemostats or right-angle clamps, will destroy a vessel and should not be used in this situation.



Wrap vessel loops around the artery and vein, proximally and distally to the injury, to gain control of the vessels.

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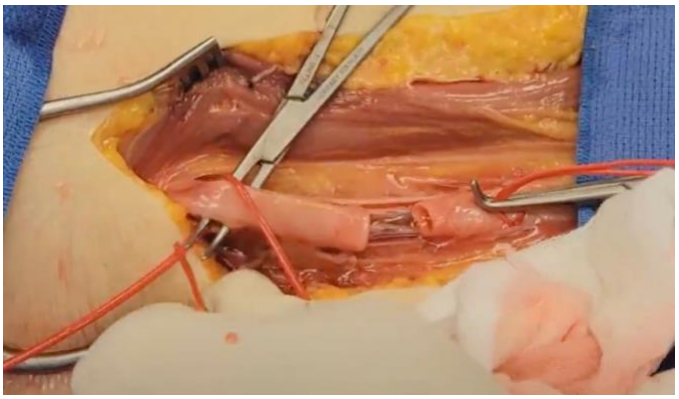
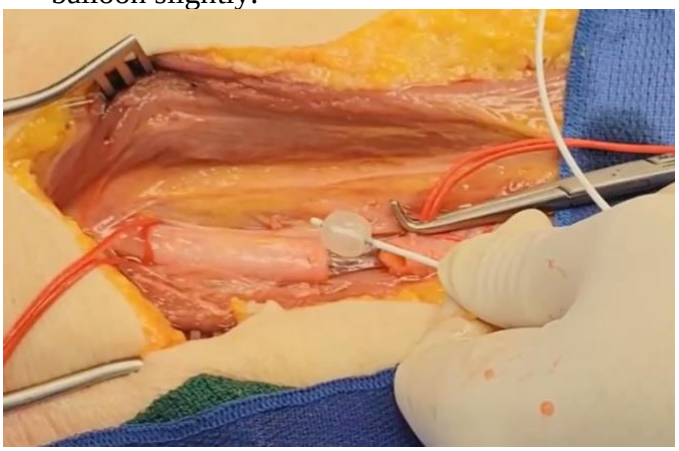
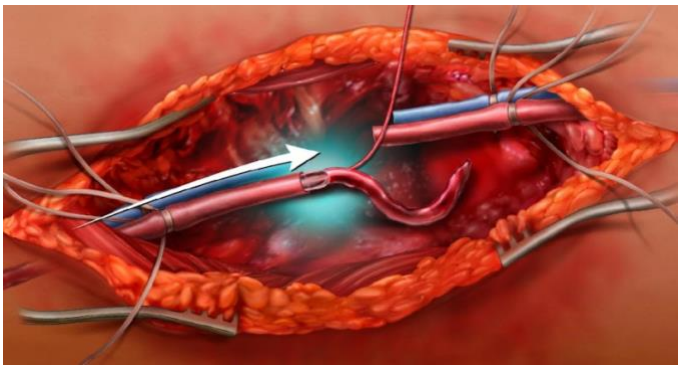


Pass the vessel loop once, grasp it and then pass it under the vessel again in the same place. Now you can pull the vessel loop snug and occlude the vessel without causing damage. This is called Pott's technique.

6. Pass a Fogarty catheter distally and proximally. First inflate the catheter outside the vessel to visualize the balloon's size relative to the amount of saline injected. Then deflate it again, insert it, inflate it, and then gently retract the catheter from vessel. You should feel only slight resistance: if there is an excess of resistance, deflate the balloon slightly.



Hold the catheter in your dominant hand and the syringe of saline in your non-dominant hand. Test the balloon by inflating it and making a note of how much saline results in the appropriate amount of inflation, to approximate the size of the lumen of the artery. Then, deflate the catheter and insert it into the vessel.



As shown here, as you pull the balloon back and it nears the transected end of the vessel, a clot will emerge. If you have removed all the clot, pulsatile bleeding will occur from a proximal vessel and non-pulsatile back-bleeding will occur from a distal vessel. If these things do not occur, pass the embolectomy catheter again.

7. Do not debride an injured vessel at the time of shunt placement- leave it until definitive repair operation to preserve vessel length.

Shunt Preparation Steps

8. Commercially available shunts are recommended; however, chest tubes and IV tubing can be used as well. Pick the largest possible arterial shunt and cut the edges smoothly so they do not damage the intima of the vessel.

Select an appropriately sized shunt (IV tubing shown here) that fits snugly into vessel and then place a suture in the center of the shunt.

9. All shunts must be carefully secured to prevent dislodgement using ties (or, less commonly, clamps or slings). This is especially important for patients requiring physical transport to another location for definitive repair.
10. Measure the length of the defect and fashion the shunt to be about 4 cm longer than the gap between the vessels. In this way, the shunt can extend about 1.5-2 cm into the proximal and distal lumens of each transected artery.

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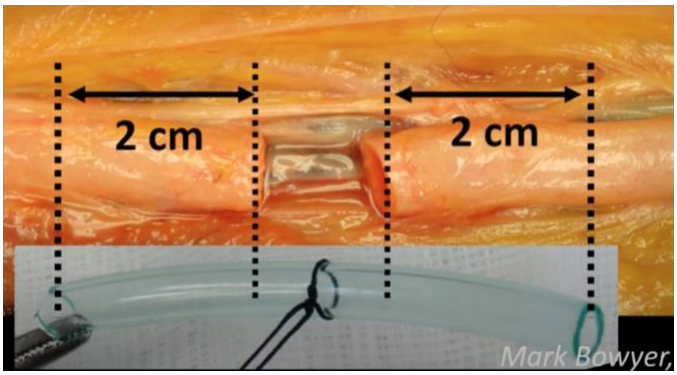
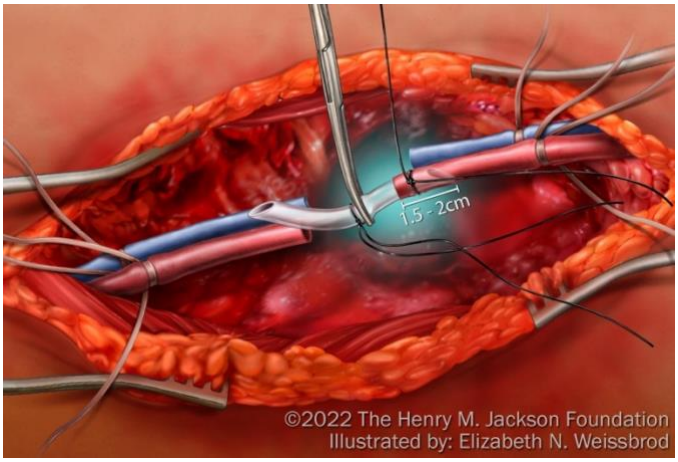


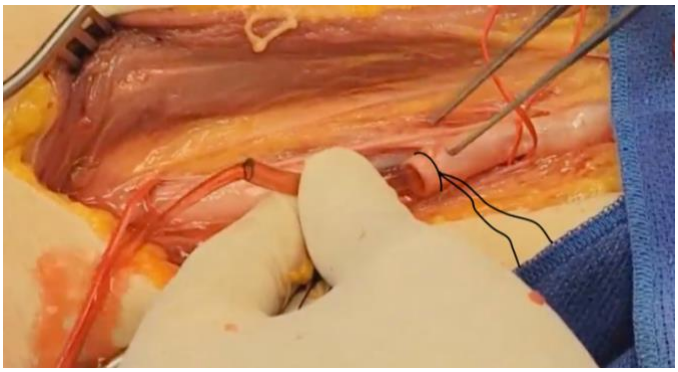
Trim the shunt to have about 2cm of length extending into both proximal and distal segments of the transected artery.

11. After trimming the shunt to the appropriate length, secure it with 2-0 silk tie in the center of the shunt and a clamped hemostat to occlude flow and serve as marker.
12. Note the transected artery typically experiences vasospasm. Therefore, topical papaverine plus gentle dilation can be used to relax the vessel, allowing larger shunt insertion.
13. Place prepared shunt 1.5-2 cm into proximal end of the transected artery and secure shunt with a 2-0 silk about 5 mm from the vessel's cut end.



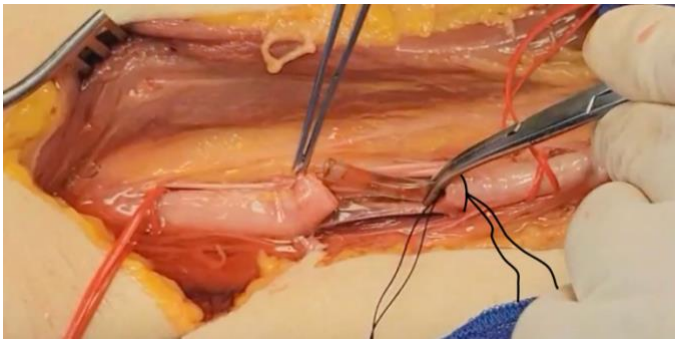
Both the silk tie and the clamp are at the center of the vessel, allowing you to control blood flow and to gauge when the shunt is inserted far enough into the vessel. Pass another silk tie around the vessel 5mm from the end and tie it, securing the shunt within the vessel.

14. Remove the clamped hemostat in center of shunt and temporarily release proximal vessel control to confirm pulsatile blood flow. Re-clamp the hemostat after confirmation.

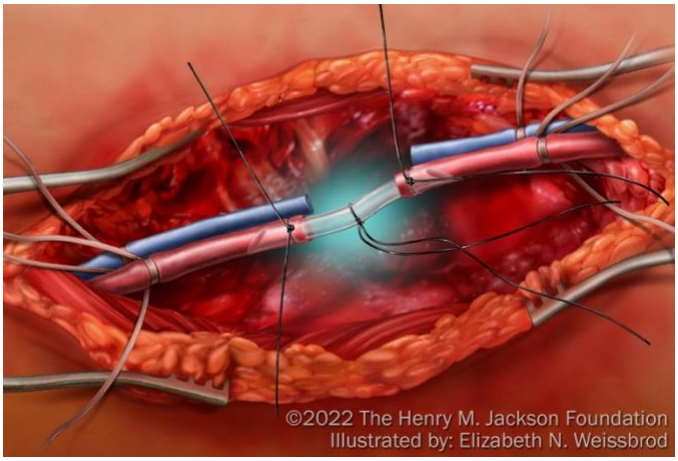


Release the clamp temporarily to confirm blood flow (this photo shows a cadaver perfused with colored saline solution.)

15. Insert the other end of the shunt 1.5-2 cm into the distal lumen of the transected vessel, compressing the vessel onto the shunt. Secure it with a 2-0 silk again, about 5mm from the vessel's cut edge. Release the vessel loop as you do this, so that the backflow removes any air from this vessel.



When inserting the other end of the shunt into the distal transected vessel, you can manipulate the shunt via the clamp at its mid-portion and the vessel by grasping it with a forceps.



After inserting the shunt into the distal end of the vessel, secure it again with a silk tie 5mm from the transected end of the vessel.

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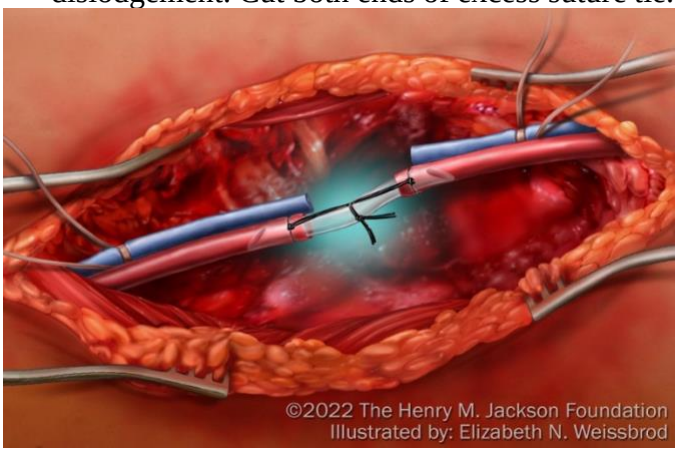
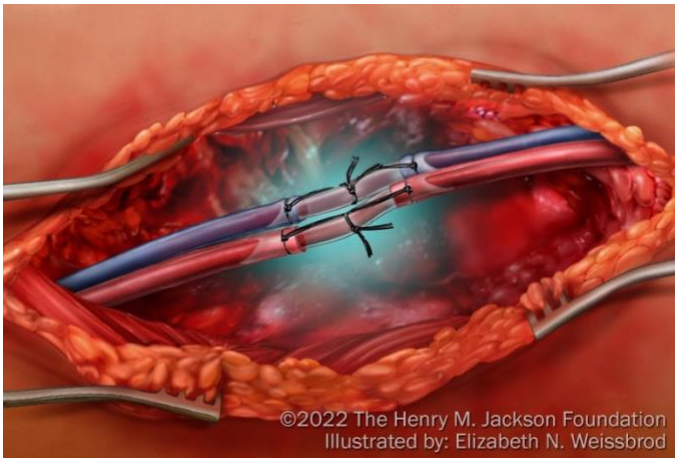
16. Join the ties under slight tension on both distal and proximal ends of the vessels. This stabilizes the shunt and helps prevent shunt migration or dislodgement. Cut both ends of excess suture tie.



Secure the shunt by tying both vessel ties to the central tie, under slight tension to prevent the shunt from becoming dislodged.

17. Release distal vascular control and confirm pulsatile flow distal to shunt placement.
18. Repeat the same procedure for the adjacent vein, if possible. Veins tolerate ligation much better than arteries, but your eventual repair has a better chance of success if it includes both the artery and the vein.



Completed shunting of both an artery and a vein.

19. After placing a shunt, be sure to document a thorough distal exam, using palpation or Doppler ultrasound if available, and note time of shunt placement.
20. Close each tissue layer using appropriate suture.

Temporary Shunt Considerations

- Shunt removal should occur as soon as the patient's physiology allows and there is appropriate surgical expertise to perform definitive repair.
- Definitive repair is necessary after temporary shunt. However, prior to definitive repair, the temporary shunt must be removed, and the vessel will require debridement back to healthy tissue beyond location where the tie was tied around the vessel (i.e. >1.5-2 cm distally and proximally of transected artery). Do not use any of the vessel that was under the ties that secured the shunt.
- It is not always necessary to heparinize vascular shunts. Additionally, not every vessel needs to be shunted. For example, there are high rates of thrombosis in shunts placed above and below the knee, without changes in rates of limb loss, indicating these vessels do not require shunting.

Ligation Considerations

Sometimes vascular shunting or repair is not possible or practical, and therefore requires ligation to gain control over life-threating hemorrhage. Most every vessel in the extremis CAN be ligated with varying levels and types of consequences. The common vessels suitable / that can tolerate ligation include but are not limited to:

- Common carotid artery
- External carotid arteries
- Subclavian artery (distal to thyrocervical trunk)
- Axillary artery
- Brachial artery (distal to profunda branch)
- Either ulnar or radial artery individually (radial is better tolerated because ulnar is generally the dominant vessel)
- Celiac trunk
- Internal iliac artery

Conversely, some vessels may not be amenable to ligation (i.e. leading to critical ischemia or stroke) and include, but are not limited to the following:

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- Internal carotid artery (~15-20% incidence of stroke)
- Superior mesenteric artery
- External iliac artery
- Common femoral artery
- Popliteal artery

Keep in mind that serious ischemia is much more likely in situations where collateral circulation is destroyed and other significant soft tissue injury exists. Lastly, regarding veins, nearly all veins can be ligated, including the inferior vena cava and the popliteal vein (which should be repaired or shunted when possible).

Definitive Vascular Repair

After a temporary shunt has been placed, or if definitive vascular repair is available at time of injury, the steps are similar to placing a temporary vascular shunt and proceed as follows:

1. After making the appropriate incisions to gain adequate exposure of the vessel, identify the injury and obtain proximal and distal control.
2. During definitive repair, debride the injured segment distally and proximally to the level of healthy vessel tissue.
3. Clear target vessel of clots by passing a Fogarty catheter (usually 3 French) proximally and distally.
4. Achieve regional heparinization with heparinized saline solution (5000 units in 100 mL normal saline), 50mL proximally, and 50 mL distally followed by reapplication of the vessel clamps.
5. Prior to definitive repair, use Potts scissors to trim the proximal and distal ends of the transected artery, with beveling of vessel as needed to make the repair.
6. Use the Fogarty catheter to gently dilate the vein graft and any small caliber arteries. Regional papaverine and/or local anesthetic can be applied to counteract any vasospasm.
7. Definitive repair is achieved by primary repair or by using a reversed autologous vein graft as conduit (a [polytetrafluoroethylene] PTFE interposition graft remains last resort.) The vascular anastomosis is performed using a running or interrupted monofilament. Although the specific techniques for making a definitive vascular repair are described elsewhere in this Manual, some types of repair include:

- Lateral arteriorraphy or venorraphy
- Patch angioplasty
- Resection with end-to-end anastomosis
- Resection with interposition graft (vein, PTFE/Dacron, CryoVein, Artegraft, etc.)
- Bypass graft
- Extra-anatomic bypass
- Stent-graft repair

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