Symptomatic Fluid Drainage: Peritoneovenous Shunt Placement

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Abstract

Ascites causes significant discomfort and has negative impact on patient's quality of life. Medical therapies including dietary restriction and diuretics are successful in only 40 to 44% of patients with malignant ascites and repeated paracentesis only provides temporary symptomatic relief. Therefore, a more permanent solution is necessary. Indwelling catheters or peritoneovenous shunt placement can provide more permanent symptomatic relief and improve patients' quality of life. Unlike indwelling catheters, peritoneovenous shunts do not limit patients' life style and therefore should be offered as first option in patients who are good candidates. Denver shunt (CareFusion-BD Worldwide) is the current available peritoneovenous shunt. In this article, the indications, contraindications, technical aspects of shunt placement, and techniques to prevent postprocedure complications will be discussed.

Keywords

- ascites
- malignant ascites
- peritoneovenous shunt
- Denver shunt
- chylous ascites

Objectives: Upon completion of this article, the reader will be able to identify patients who are best candidates for peritoneovenous shunt placement, the contraindications, technical aspects of shunt placement, and techniques to prevent postprocedure complications.

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In 1962, Smith used a Holter valve to form a peritoneovenous shunt (PVS) and successfully treated ascites caused by portal cirrhosis.¹ Based on the same concept, LeVeen used a pressure-sensitive unidirectional mechanical valve shunt with two limbs connecting the peritoneal cavity to the central venous circulation.² LeVeen's shunt was placed surgically

and worked based on the different pressure gradients between the higher pressure abdominal cavity and the lower pressure central venous system resulting in transferring ascites fluid from the peritoneal cavity into the central venous circulation. He was able to successfully treat refractory ascites in cirrhotic patients.³ In 1979, Lund and Newkirk designed a new PVS that had a manual compressible valve chamber between the peritoneal limb and the venous limb.⁴ The valve provided a unidirectional flow of fluid and prevented reflux of blood into the peritoneal cavity. The manually compressible valve helped clear the tubes from debris preventing high rate of occlusion observed with LeVeen's shunt. The most recent version of PVS is called the *Denver shunt* (CareFusion, BD Worldwide) that has completely replaced LeVeen's shunt and has been successfully used in treating intractable ascites in both cirrhotic and cancer patients.^{5–12}

Shunt Features

The shunt is made of two Silastic tubes connected by a compressible pump (► **Fig. 1**). One catheter which has an end hole is placed in a central vein (subclavian or jugular vein) and the other catheter which is fenestrated is placed in the peritoneal cavity. Denver shunt is available in two sizes,

Fig. 1 Denver shunt is made of two Silastic catheters that are connected by a pump (black arrow). The fenestrated end (dotted arrow) is placed in the peritoneal cavity and the end-hole catheter (arrow heads) is placed in a central vein, i.e., jugular vein.

11.5 French (F) and 15.5F. The pump is either single valved or double valved. The valve opens once the pressure differential is more than 3 cm H₂O. The shunt transmits fluid from the peritoneal cavity into the central venous system. The single-valve pump provides faster flow rates compared with the double-valved pumps. The 11.5F catheter single valve has an anticipated flow rate of 30 to 40 mL/min compared with 20 to 30 mL/min in the double-valve shunt. The 15.5F shunt anticipated flow rate is 40 to 55 mL/min for single-valve shunt and 25 to 40 mL/min for double valved. The 15.5F catheter is used when internal jugular vein is used and 11.5F catheter is used when saphenous or subclavian veins are used. The 15.5F catheter is less likely to occlude and the double valved is more effective in preventing reflux; therefore, 15.5F double-valve shunt is the most commonly used shunt. The single-valve shunt is used when the ascites fluid is very viscous or when there is very high daily ascites fluid production.¹³

The advantages of PVS over other methods of treatment are as follows:

1. The procedure is simple and will be explained in detail in section "Shunt Placement Technique"; in brief, the procedure is a combination of two procedures: central venous catheter placement and tunneled drainage catheter placement.
2. No external device is extended out of the patient. The entire shunt is subcutaneous. Therefore, unlike indwelling tunneled drainage catheters such as Pleurx or Tenckhoff catheters, PVS does not limit the patient's quality of life and the patients are able to submerge in water including swimming and bathing.¹⁴
3. There is no fluid or loss of nutrients with PVS. One of the main problems with paracentesis and indwelling tunneled catheters is loss of nutrients and the risk of developing malnutrition. Since the shunt returns all of the fluid drained from the peritoneal cavity back into the patient's venous system, there is no loss of nutrients.^{14,15} In most recent study on PVS in patients with chylous ascites, the patients' nutritional status improved after shunt placement and the serum albumin level significantly increased following shunt placement.¹⁶

4. In patients with chylous ascites due to retroperitoneal lymph node dissection, PVS placement may provide permanent treatment with complete resolution of ascites.¹⁶

Patient Selection: Indications and Contraindications

Indications

Patient selection is the most important step in PVS placement. Meticulous patient selection increases the success rate and prevents postprocedure complications. The operator should have sufficient amount of knowledge about the indications and contraindications of PVS placement. ►Table 1 demonstrates the indications and contraindications for PVS placement.^{17,18} The two main groups of patients who are candidates for PVS placement are as follows:

1. *Patients with intractable malignant or cirrhotic ascites* not responding to medical treatment and repeated large volume paracentesis. Medical therapy includes fluid and salt restriction (fluid restriction to 1,500 mL/day and salt restriction to 80 mmol/day) and diuretic therapy (400 mg/day of spironolactone or 300 mg/ of triamterene plus 120 mg/day of furosemide). Medical therapy failure is when ascites does not respond to this regimen after 4 weeks of therapy. Failure to repeated larger volume paracentesis is when patient requires paracentesis every 7 to 10 days. Patients should have at least 3 months of life expectancy.
2. *Patients with chylous ascites* are the second group who benefit from PVS placement. Chylous ascites may result from surgical retroperitoneal lymph node dissection, malignancies such as lymphoma or metastasis, and radiation therapy.¹⁹ Medical therapy and large volume paracentesis are not effective in these patients and may result in malnutrition. PVS improves nutritional status in these patients by preserving the high-protein chylous ascites. Additionally, unlike non-chylous ascites patients, disseminated intravascular coagulation (DIC) has not been reported in these patients. Finally, PVS may lead to permanent resolution of ascites in many of these patients, allowing for shunt removal.¹⁶

Contraindications

Contraindications are as important as selecting best candidates. ►Table 1 demonstrates the list of relative and absolute contraindications of shunt placement.^{17,18,20} Contraindications are based on the risk of development of postprocedure complications due to return of the peritoneal fluid resulting in volume overload and disseminated intravascular coagulopathy or complications related to the shunt, that is, shunt occlusion.

Contraindications Due to Volume Overload

Decompensated congested heart failure (CHF) is an absolute contraindication for PVS placement. These patients are at risk of developing pulmonary edema after shunt placement. Compensated CHF is a relative contraindication. This is based on the fact that the heart might not be able to manage the extra fluid returning from the peritoneal cavity and

Table 1 Indications and contraindications for Denver shunt placement

Indications
<ul style="list-style-type: none"> • Intractable malignant or cirrhotic ascites not responding to medical treatment and large volume paracentesis • Life expectancy of more than 3 mo • Chylous ascites • None of the contraindication exists
Contraindications
Relative contraindications
<ul style="list-style-type: none"> • Compensated congestive heart failure • Loculated ascites or peritoneal adhesions • Peritoneal disease, i.e., peritoneal mesothelioma • Massive pleural effusion • Varices with no history of bleeding • Portal hypertension • Positive cytology of the ascites fluid • Simultaneous gastrointestinal surgery
Absolute contraindications
<ul style="list-style-type: none"> • Bloody ascites • Renal failure if the patient is not on dialysis • History of varicose vein bleeding • Grade 3/4 esophageal varices • CHF or advanced cardiac disease • Respiratory failure with pulmonary edema • Liver failure (T Bili > 2.0 mg/dL) • Coagulation disorders (Low platelet counts < 50 × 10⁹ or high INR > 2.0) • Peritonitis or history of spontaneous bacterial peritonitis • Evidence of nonsterile ascites (from bile leak or urine leak) • Poor performance status • Anasarca or hypoalbuminemia (serum albumin < 2.5 g/dL)

Abbreviations: CHF, congested heart failure; INR, international normalized ratio; T Bili, total bilirubin level.

decompensate. Close hemodynamic monitoring is essential if decision is made to proceed with shunt placement.

Patients with renal insufficiency who are not on dialysis are absolute contraindication for shunt placement as they may develop volume overload. Sufficient renal function prior to shunt placement is associated with better postprocedure outcome.²¹

Patient with a history of variceal bleeding have significantly higher risk of rebleeding after shunt placement and approximately 47% of these patients die from the rebleed.¹⁸ Therefore, any history of variceal bleeding is an absolute contraindication for shunt placement. These patients are better candidates for transjugular intrahepatic portosyste-

mic shunt placement.¹⁸ Patients with grade 3/4 esophageal varices also have higher risk of bleeding after shunt placement, most likely from volume overload resulting in increased pressure in the varices.⁹

Hypoalbuminemia (serum albumin <2.5 g/dL) may result in anasarca which is associated with impair healing.

Contraindications Due to Increased Risk of Postprocedure Occlusion/Malfunction

If a patient has loculated ascites or peritoneal adhesions, the shunt might drain only a part of the abdomen and not the entire abdomen. Therefore, there is higher incidence of postprocedure shunt occlusion. Additionally, there is a higher risk of postprocedure shunt occlusion in patients with peritoneal disease like peritoneal mesothelioma.^{16,17} Therefore, these patients should be informed prior to the procedure that they might need multiple revisions.

High protein content in the ascitic fluid (> 4.5 g/L) used to be a contraindication to shunt placement due to higher incidence of occlusion; however, with the use of the 15.5F catheters, this is no longer a contraindication. Some authors have categorized positive cytology of ascites fluid as a relative contraindication for shunt placement.¹⁷ This was mainly based on the results obtained from a small retrospective study that demonstrated more complications, particularly occlusion, in patients with positive cytology compared with negative cytology.

History of spontaneous bacterial peritonitis or any evidence of systemic infection is contraindication for shunt placement due to the increase risk of postprocedure infection and sepsis.¹⁷

Contraindications Due to Increased Risk of Postprocedure DIC

Bloody ascites is one of the most important absolute contraindications for shunt placement.^{6,8} These patients have high risk of developing DIC.

Liver failure is an absolute contraindication. Elevated bilirubin can be used as a surrogate for liver failure. Prior studies have suggested that rising bilirubin or bilirubin > 10 mg/dL is an absolute contraindication.¹⁷ In our experience, serum total bilirubin of more than 2 mg/dL was associated with significantly higher rate of postprocedure complications.¹⁶

Shunt Placement Technique

Patients are admitted overnight and observed for postprocedure complications particularly related to volume overload and DIC. Some authors perform the procedure as an outpatient procedure. However, we prefer to admit the patient for at least one night. Laboratory values that are checked prior to the procedure are as follows: complete blood cell count (CBC), coagulation profile (including prothrombin time, international normalized ratio, and active partial thromboplastin time), blood urine nitrogen, creatinine, serum albumin level, and liver function tests including total bilirubin level. In addition to the aforementioned laboratory values, we also check DIC profiles which include fibrinogen

and D-dimer levels. CBC will be checked every 12 hours postprocedure and the rest of the laboratory values will be checked daily till the patient is discharge. CBC is checked to monitor the platelet number and the DIC profile is used to diagnosis any possible postprocedure subclinical or overt DIC. All patients receive a prophylactic intravenous antibiotic (first-generation cephalosporin).

Moderate sedation is used. The entire anterolateral aspect of the patient's body from below the mandible to the groin is prepped and draped (►Fig. 2a). The side of prepping is based on where the most ascites fluid is located. Three incisions are made. The first one is at the upper abdominal region. Through this incision, a 12F all-purpose drainage (APD) catheter is inserted and the ascites fluid is drained close to completion, leaving only a small amount of ascites to prime the shunt (►Fig. 2b). The APD catheter is ultimately exchanged for the peritoneal limb of the shunt. The peritoneal limb is placed in the most dependent region of the pelvic cavity. If too much ascitic fluid is drained, 1 L of warmed saline can be injected into the peritoneal cavity and used to prime the shunt. The second incision is made on a firm noncompressible rib in the lower rib cage (►Fig. 2c). The incision should be at least 3 cm above the location we plan to place the pump. Patients are asked to compress the pump immediately after shunt placement and therefore if the

incision is too close to the pump, patients would experience significant amount of pain that would prevent them from compressing the pump. The pocket for shunt is made using the same technique used for MediPort placement. A third and final incision is then made at the venous access site. We recommend the 15.5F catheter and therefore recommend using the internal jugular vein. The pump is pushed into the pocket and through the superior aspect of the incision, the venous limb of the shunt is tunneled under the skin using long metallic tunneler that is provided by the Denver shunt kit. The tip of the venous limb of the shunt should end in the proximal right atrium. The length of the venous catheter is meticulously measured using the same technique used in central venous catheter placement. The compressible pump should be placed on a firm, noncompressible area of the lower rib cage. This is because the patient would be able to compress the pump against the rib.

The site of the pump is marked for the patient and the nurses (►Fig. 2d). Patients are instructed to pump the shunt 20 times twice a day, while the patient is lying supine. This provides maximum flow through the shunt.

Final images from the venous limb (with the tip of the catheter located at the proximal right atrium), the pump and the peritoneal limb (with the tip of the catheter located in the pelvic region) are obtained (►Fig. 3a–c).

Fig. 2 (a) The patient's largest pocket of fluid was in the right side and therefore the right abdomen was prepped from below the mandible down to the groin. (b) Incision is made on the right upper abdomen and a 12F all-purpose catheter is inserted (black arrow). The ascites is drained through this catheter. (c) A noncompressible rib on the lower rib cage is identified and 3 cm cranial to it a 3-cm-wide incision is made (black arrow). (d) The site of the pump is marked for the patient and the nurses (marked as X). The upper abdominal incision (black arrow) is sutured and the pump incision located 3 cm superior to where the pump is placed is also sutured (dotted arrow).

Fig. 3 (a) The venous limb of the Denver shunt should be placed with the tip of the catheter (white arrow) located in the proximal right atrium. (b) Spot fluoroscopy image from the pump (white arrow) demonstrates no evidence of kinking throughout the shunt. (c) Spot fluoroscopy image from peritoneal limb of the shunt demonstrates the tip of the catheter (white arrow) within the pelvic region.

Postprocedure Complications and Preventive Techniques

Since the 1970s when LeVeen surgically placed his shunt, there has been extensive amount of modifications in the shunt placement technique and also in the shunt design to prevent the three main complications of shunt placement: occlusion, DIC, and volume overload. These modifications help prevent complications and have made PVS a safer treatment modality. These include:

1. Percutaneous placement of the shunt.
2. Complete drainage of the ascites fluid at the time of the procedure.
3. Jugular vein access.
4. The distal tip of the venous catheter should be placed proximal to the right atrium.

Percutaneous Placement of the Shunt

Percutaneous placement of PVS has multiple advantages over surgically placed technique. Percutaneous technique is less invasive, faster, less expensive, and eliminates the need for general anesthesia.²¹ The percutaneous technique is well tolerated with minimal pain, and the patients are discharge in 1 to 2 days. At some institutions, the procedure is performed as an outpatient procedure.

Complete Drainage of the Ascites Fluid at the Time of the Procedure

When LeVeen first started his shunt placement, one of the most important steps was to perform a purse suture around the peritoneal access site to prevent spillage of the ascites fluid. After the shunt was placed, all of the ascites fluid was returned to the venous circulation. LeVeen believed that the ascites fluid is needed to keep the shunt open. However,

increased intravascular volume was associated with high rate of postprocedure DIC, CHF, variceal bleeding, and pulmonary edema.^{9,21} The current recommendation has changed and now we recommend removing almost all the ascites fluid and sometime completely replacing it with 1 L of warm saline prior to shunt placement. This modification has been able to significantly decrease the risk of postprocedure DIC, from 20 to 50% in early surgically placed shunts to 0 to 9% in most recent reports where complete drainage of ascites was performed.^{5,8,14,21-24}

Won et al demonstrated that the amount of ascites removed significantly correlated with frequency of postprocedure variceal bleeding.⁹

Jugular Vein Access

Subclavian and axillary veins were the most common venous access sites. These veins are more prone to develop catheter fragmentation or "pinch-off syndrome," occlusion or thrombosis.^{13,25} However, studies have shown that jugular vein when accessed under ultrasound guidance is associated with lower complication rates.²¹

Distal Tip of the Venous Catheter Placed Proximal to the Right Atrium

One of the most problematic complications of the venous limb is thrombosis of the tip of the catheter which may result in shunt occlusion or possible pulmonary embolism.²⁶ Meticulous measurement of the length of the venous limb is an important step in preventing this complication. The turbulent flow of the right atrium is thought to prevent accumulation of clot around the tip of the catheter.²⁷ Studies have demonstrated that the catheter tip patency doubles when the tip of the catheter is positioned in the proximal atrium compared with when it was placed at the cavoatrial junction.²⁸

Conclusion

In summary, PVS is almost 100% effective in providing immediate symptomatic relief in malignant and chylous ascites with acceptable rate of major complications ranging from 0 to 5%, including DIC (0–5%), pulmonary edema (0–5%), and pulmonary embolism (0–5%).^{15,16,21,29,30} The shunt dramatically improves the quality of life of these patients.³⁰ The outcomes demonstrate significant improvement from early report on surgically placed PVS in which complication rates were in the range of 20 to 35% for early shunt occlusion, 3 to 18% for infection, and more than 20% for procedural mortality.^{4,15}

Conflict of Interest

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