Paracentesis-Induced Circulatory Dysfunction: A Primer for the Interventional Radiologist

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Abstract

Keywords

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- ascites
- complication
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Paracentesis-induced circulatory dysfunction is a complication of large volume paracentesis that leads to faster reaccumulation of ascites, hyponatremia, renal impairment, and shorter survival. Knowledge of the pathophysiology, clinical presentation, diagnosis, and prevention of this condition is vital to the interventional radiologist as a valued team member in the treatment of ascites.

Liver cirrhosis is the most common condition resulting in ascites, and ascites is the most common complication of cirrhosis. Ascites is associated with decreased quality of life, increased risk of infection, renal impairment, and overall decreased survival.^{1–3} Patients with massive ascites frequently present with abdominal discomfort, shortness of breath, decreased appetite, spontaneous bacterial peritonitis, and abdominal wall hernias.^{4,5} In addition to dietary management (e.g., sodium and fluid restriction, and abstinence from alcohol) and diuretics, therapeutic paracentesis is a common therapy in the setting of ascites, particularly for patients with massive and refractory ascites.^{1,5}

The goal of paracentesis should be to provide symptomatic relief that lasts as long as possible while at the same time preventing complications such as paracentesis-induced circulatory dysfunction (PICD). PICD was first described by Ginsè al⁶ in 1988, and usually occurs following large-volume paracentesis (> 5–6 L) and result in faster reaccumulation of ascites, hyponatremia, renal impairment, and shorter survival. The incidence of PICD approaches 80% when a large-volume paracentesis is performed without additional therapeutic management; the incidence is reduced to 15 to 35% when volume expanders (discussed below) are used. Knowledge of the pathophysiology, clinical presentation, diagnosis, and prevention of PICD will assist the interventional radiologist in the

proper clinical management of patients with massive and refractory ascites.

Pathophysiology

The exact pathophysiology of PICD is not entirely understood. PICD was initially thought to occur secondary to fluid shifting after paracentesis, resulting in decreased circulating volume.⁷ Although, simple fluid shifting may be contributory, additional studies demonstrated that decreased systemic vascular resistance also plays an essential role in PICD.^{8–10} One of the causes of decreased systemic vascular resistance is believed to result from increased nitric oxide synthesis secondary to shear stress caused by increased cardiac output postparacentesis.¹¹ Increased cardiac output is also believed to lead to a reflex mechanism of decreased systemic vascular resistance, possibly through short-term downregulation of the sympathetic nervous system and renin release secondary to cardiac volume receptor activation.¹² Decreased intra-abdominal pressure is another possible contributing factor to the decreased systemic vascular resistance¹³ after paracentesis.

The resulting effective hypovolemia due to arteriolar vasodilation in turn leads to a prolonged activation of the sympathetic nervous system and the renin-angiotensin-aldosterone pathway. Increased plasma renin activity in particular is

characteristic of PICD, however general hyporesponsiveness to vasoconstrictors in the setting of cirrhosis decreases the ability to compensate for the accentuated vasodilation.¹⁴ Patients who are unable to fully compensate for the systemic vasodilation are more likely to develop PICD⁹; the homeostatic effects of PICD can last for months.^{15,16}

Clinical Presentation and Diagnosis

Although considered a clinically silent syndrome, PICD is an independent predictor of mortality in patients with massive ascites treated with large-volume paracentesis.^{15,16} Patients with PICD reaccumulate ascites and experience a return of symptoms (e.g., abdominal discomfort, shortness of breath, decreased appetite) more rapidly after paracentesis. In addition, patients are more likely to develop hepatorenal syndrome and hyponatremia and have an overall decreased survival as compared with patients who do not develop PICD.¹⁶

PICD is definitively diagnosed through laboratory results, with increases of more than 50% of baseline plasma renin activity to > 4 ng/mL/h on the 5th to 6th days after paracentesis.^{9,16}

Prevention/Treatment of PICD

Many authors believe that methods to prevent PICD should routinely be employed given the potential adverse consequences.¹⁷ One of the simplest ways to prevent PICD is to limit the volume of fluid removed to 5 to 6 L at a time.^{16,18,19} Reducing the flow rate of fluid removed during the paracentesis is also theorized to decrease the incidence of PICD.¹¹ However, preventative treatment of PICD largely centers on the use of plasma volume expanders postparacentesis. Albumin, saline, dextran-70, hydroxyethyl starch, and polygeline have all been used as volume expanding agents, but albumin has been shown to be superior when paracentesis volume removal exceeds 5 to 6 L.^{16,19} One recent meta-analysis concluded that albumin was superior to other volume expanders and alternative treatments in decreasing the risk of PICD, hyponatremia, and mortality.¹⁵ A separate recent meta-analysis demonstrated the benefit of albumin administration in decreasing the incidence of PICD after paracentesis as well as morbidity and mortality in patients with any type of infection.²⁰ The American Association for the Study of Liver Diseases guidelines state that it is reasonable but not mandatory to give 6 to 8 g of albumin per liter of ascites removed when more than 5 L are removed.

A concern with the administration of albumin is the added cost as well as the small infectious risk. A recent small study demonstrated no difference in PICD, hyponatremia, renal impairment, rate of ascites recurrence, and 6-month survival in patients receiving standard versus half albumin doses²¹; if confirmed in a larger study, this albumin infusion adjustment could help decrease costs in treating with albumin.

Vasoconstrictor use is another developing strategy in preventing PICD. Terlipressin, a vasopressin analogue, has been shown in two early pilot studies to be as effective as

albumin in reducing PICD^{22,23} and has been shown recently to have a synergistic effect with albumin in controlling ascites.²⁴ Data regarding other vasoconstrictors are less convincing. Conflicting reports have been published on midodrine, an α -adrenoreceptor agonist, regarding its ability to prevent PICD.^{22,25} Recent data regarding satavaptan, a vasopressin II receptor antagonist, suggests that there is no significant benefit in preventing the worsening or recurrence of ascites with its use and that there may be a slight increased risk of mortality when using satavaptan in the setting of cirrhosis.²⁶ Nonselective β -blockers, such as propranolol, have widely been the cornerstone of medical management in cirrhosis, but recent studies suggest an increased risk of PICD and mortality in patients with refractory ascites,^{27–29} bringing into question its use in this subset of patients.

Conclusion

PICD occurs as a complication of large volume paracentesis. PICD largely results from accentuated arteriolar vasodilation and decreased systemic vasodilation that result in compensatory increases in sympathetic nervous system activity and renin release. PICD is a clinically silent syndrome but is associated with faster reaccumulation of ascites, hyponatremia, renal impairment, and shorter survival. Albumin administration when paracentesis volume removal exceeds 5 L has been shown to decrease the incidence PICD, hyponatremia, and mortality in patients with cirrhosis undergoing large-volume paracentesis. The American Association for the Study of Liver Diseases guidelines states that treating with 6 to 8 g of albumin per liter of ascites removed (when more than 5 L of ascites are removed) is reasonable but not mandatory. Some recent data regarding vasoconstrictor use in preventing PICD suggest some benefit for terlipressin, are inconclusive for midodrine, and suggest no significant benefit (and a possible increased risk of mortality) with satavaptan. Knowledge of the pathophysiology, clinical presentation, diagnosis, and prevention of PICD is vital to the interventional radiologist as a valued team member in the treatment of ascites.

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