

# Synthetic Colloid Fluids & Volume Expansion

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## P Profile

### Definition

- Natural colloid particles in plasma are proteins (eg, albumin, fibrinogen, globulins).
- Albumin contributes the most to intravascular colloid osmotic pressure (COP), as it is the most abundant protein in plasma and has a negatively charged arm that attracts positive sodium ions and water.
  - The primary use of albumin-containing colloid solutions (eg, concentrated human or canine albumin) is for albumin replacement, not volume expansion.
- Other fluids that contain protein-based large-molecular-weight particles include hemoglobin-based oxygen carrying solutions (eg, Hemoglobin-glutamer-200) and human intravenous immunoglobulin G (IVIG).
- Synthetic colloid fluids (**Figure 1**) are manufactured large-molecular-weight particles (eg, gelatins, dextrans, hydroxyethyl starch [HES] solutions).
  - Gelatins have a small average molecular weight (30 kD).
  - Dextrans are polysaccharide chains of glucose used for acute intravascular volume expansion, as an antithrombotic agent during vascular surgery<sup>1</sup> (by inhibiting tissue plasminogen activator, reducing platelet adhesion to von Willebrand factor, and reducing platelet activation by thrombin), and to solubilize certain agents (eg, iron).

### Definitions at a Glance

- **Colloid fluids:** Solutions containing colloid particles that are too large to cross the functional endothelial membrane.
- **Colloid osmotic pressure (COP):** The osmotic pressure generated by colloids.
- **Crystalloid fluids:** Solutions of water and dissolved small-molecular-weight particles (eg, sodium, glucose).
- **Osmosis:** The process by which small-molecular-weight particles attract and hold water molecules when contained within an impermeable membrane.

- The most commonly used synthetic colloid solutions in United States practice are HES solutions (see **Table**, next page).
  - HES solutions are primarily used for acute intravascular volume expansion and intravascular COP maintenance. They are also used during cardiopulmonary bypass surgery for isovolemic hemodilution,<sup>2</sup> during plasmapheresis and leukapheresis,<sup>3</sup> and to prevent cellular desiccation during cryopreservation.<sup>4</sup>
  - There are 2 preparations (Dextran-40, Dextran-70) with an average molecular weight of 40 and 70 kD, respectively. Dextrans are no longer used for volume expansion in the United States because of increased risk for renal failure in humans.<sup>5</sup>



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Synthetic colloid solution (HES).  
Courtesy Abbott Animal Health

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COP = colloid osmotic pressure, HES = hydroxyethyl starch, IVIG = intravenous immunoglobulin G

- ❑ HES is a potato- or corn-derived modified amylopectin with hydroxyl-groups on the glucose molecule substituted with hydroxyethyl groups (HEGs).
- ❑ Molar substitution (MS) is the number of HEGs per glucose molecule.
  - When 4 HEGs per glucose molecule are present, the solution is a tetrastarch.
  - When 7 HEGs per glucose molecule are present, the solution is a hetastarch.
- ❑ The initial intravascular volume expanding effects of HES solutions will be greatest on the solution with a lower average molecular weight and higher concentration, as more particles in solution will increase the initial osmotic effect.
- ❑ The makeup of the HES molecular structure can be manipulated to affect average molecular weight, concentration, degree of MS, and C2:C6 ratio.

**Fluid Fact**

In the extracellular fluid, sodium ions provide the largest concentration of small-molecular-weight particles but move freely across the functional endothelium.

- The C2:C6 ratio reflects the number of HEGs at the carbon-2 position compared with the carbon-6 position on the molecule's carbon ring.
- The greater the C2:C6 ratio, the more difficulty for amylase to break down intramolecular bonds.

**Medications**

- Plasma COP holds water within the intravascular space and supports the conduit through which nutrients, blood cells, and oxygen can be delivered to tissues.
- Any condition that causes a decrease in

albumin concentration will result in a decreased COP and decreased intravascular volume retention capabilities.

- As intravascular COP declines, water can flow into the interstitium, resulting in intravascular volume depletion and interstitial edema (see **Causes of Decreased Intravascular COP**).
- With conditions that cause increased albumin loss, albumin-containing solutions may not be as effective at increasing and sustaining plasma COP as higher-molecular-weight synthetic colloids such as HES.
  - ❑ Administered albumin will redistribute into the interstitial space and be lost into third spaces.<sup>6</sup>

**Table****HES Solutions in the United States**

	6% HES 600/0.75 (HESpan; bbraunusa.com)	6% HES 670/0.75 (HeXtend; hospira.com)	6% HES 130/0.4 (VetStarch; abbottanimalhealth.com)
<b>COMPOSITION</b>			
Sodium (mEq/L)	154	143	154
Chloride (mEq/L)	154	124	154
Lactate (mEq/L)	-	28	-
Calcium (mEq/L)	-	5	-
Potassium (mEq/L)	-	3	-
Magnesium (mEq/L)	-	0.9	-
Dextrose (g/L)	-	0.99	-
<b>PROPERTIES</b>			
M <sub>w</sub> (kD)	600	670	130
MS	0.75	0.75	0.4
C2:C6 ratio	4.6:1	4.5:1	9:1
pH	5.9	5.9	4–5.5
Calculated osmolarity (mOsm/L)	309	307	308

COP = colloid osmotic pressure, HEG = hydroxyethyl group, HES = hydroxyethyl starch, MS = molecular substitution

## Causes of Decreased Intravascular COP

### Decreased production (liver failure)

- Portosystemic shunt
- Chronic active hepatitis
- Acute hepatotoxicity

### Increased loss

- Protein-losing glomerulonephropathy
- Protein-losing enteropathy
- Systemic inflammatory response syndrome
- Acute allergic reaction

### Precautions

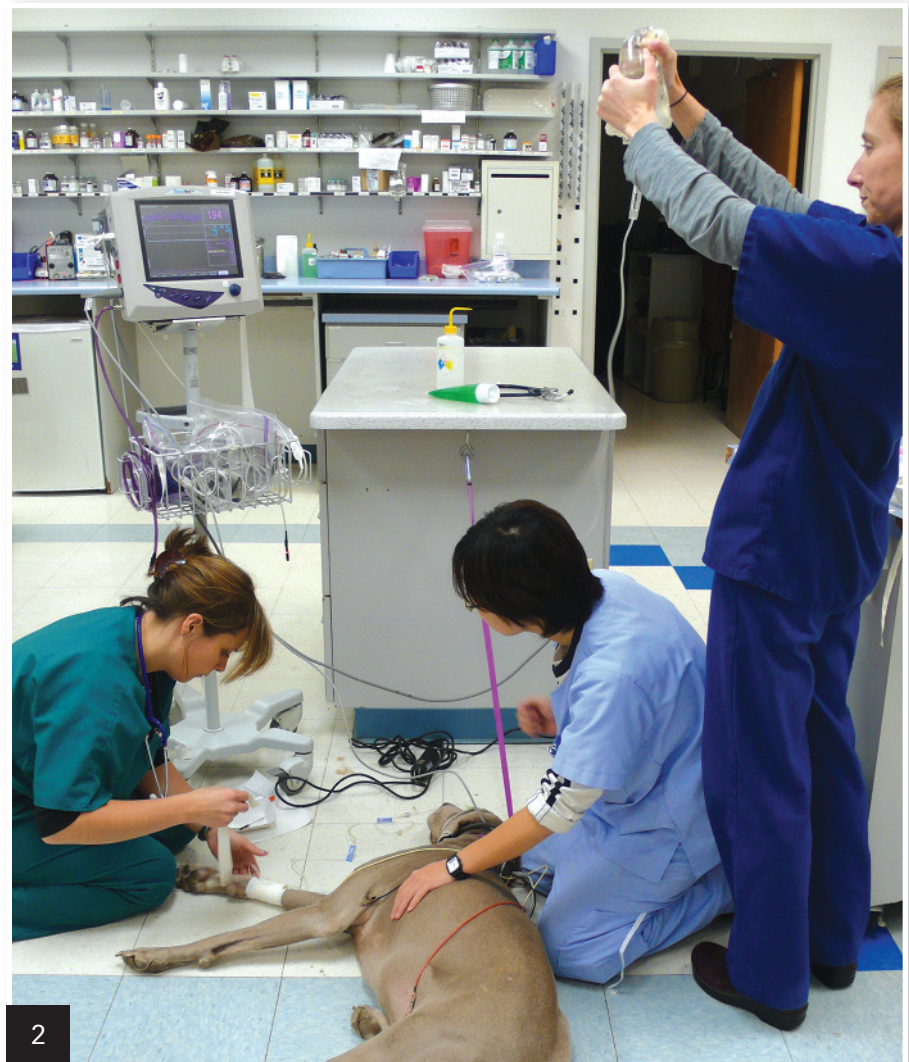
- At the recommended doses, the author has not seen clinically relevant bleeding attributable to HES.
- Data analysis has suggested that, like other hyperoncotic solutions, 10% HES solutions can negatively affect renal function.<sup>7</sup>
- Acute kidney injury in small animals attributed to HES has not been documented.

### Suggested Dosages

- Colloid fluids are typically administered in conjunction with isotonic crystalloid fluids (Figure 2).
- To meet individual fluid needs and avoid exceeding tolerances for administered fluid volumes, end-point resuscitation goals need to be established.<sup>8</sup>
  - In hypovolemic dogs and cats without acute hemorrhage and in dogs and cats with brain injury, the goal is typically to restore normal perfusion parameters.
  - In hypovolemic dogs and cats with acute hemorrhage, the goal may be to restore perfusion parameters to near-normal (ie, heart rate <160 bpm, mean arterial blood pressure ~60 mm Hg, systolic blood pressure ~80 mm Hg) to avoid disturbing a tenuous clot on a bleeding vessel.
  - If blood loss is significant, the ideal treatment may be a blood transfusion.

- For all cats and for dogs that may be less fluid tolerant (eg, because of acute hemorrhage; oliguric renal failure; cardiac, pulmonary, or brain disease), small volume aliquots may be used (eg, 3–5 mL/kg HES with 10–15 mL/kg isotonic crystalloid).
- For dogs that are expected to be more fluid tolerant, large-volume aliquots may be used (eg, 10–20 mL/kg HES with 20–40 mL/kg isotonic crystalloid).
- Fluid volume aliquots are administered as rapidly as possible in dogs.

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Rapid fluid infusion in a dog.

## Fluid Fact

Natural and synthetic colloid fluid solutions are crystalloid fluids containing large-molecular-weight particles that augment plasma COP.

- As soon as the aliquot infusion is completed, the patient is reevaluated.
  - If the end-point goal has not been met, an additional fluid volume aliquot is indicated.
- Cats are often hypothermic in conjunction with hypovolemic shock.
  - A large-volume fluid infusion can result in signs of fluid intolerance.
    - Initial low-volume aliquots of HES and isotonic crystalloid fluids are therefore administered over 5–10 minutes until the systolic arterial blood pressure is  $\geq 50$  mm Hg.
  - Maintenance and rehydration rates of isotonic crystalloid and colloid fluids are continued while aggressive rewarming techniques are employed until achieving normothermia.
- In normovolemic hypocoagulable patients, HES may be administered at 20–30 mL/kg over 4–6 hours to bolster plasma COP and maintain intravascular fluid expansion.
- When using HES during fluid resuscitation, it may be continued via CRI at 20–30 mL/kg/day to maintain plasma COP until underlying cause of reduced COP has been corrected.
- Signs associated with fluid intolerance may begin as serous nasal discharge and chemosis, progressing to peripheral edema, shivering, moist lung sounds and/or cough, and tachycardia or bradycardia.
- Reevaluation allows for early identification of signs associated with fluid intolerance, cardiovascular destabilization, and need for repeat resuscitation efforts.
- When large volumes of crystalloid fluids (eg, 90 mL/kg in dogs, 60 mL/kg in cats) and HES (eg, 30 mL/kg) fail to achieve resuscitation end points, causes of persistent circulatory shock should be investigated (see **Causes of Persistent Circulatory Shock**).



## In General

## Relative Cost

## Cost Key

\$ = up to \$100  
 \$\$ = \$101–\$250  
 \$\$\$ = \$251–\$500  
 \$\$\$\$ = \$501–\$1000  
 \$\$\$\$\$ = more than \$1000

- Hetastarch: \$–\$\$
- 6% HES 130/0.4 in 0.9% sodium chloride injection (VetStarch; abbottanimalhealth.com): \$–\$\$
- Plasma COP, plasma albumin, indirect arterial blood pressure: \$ ■ **cb**

See **Aids & Resources**, back page, for references & suggested reading.

## Causes of Persistent Circulatory Shock

Inadequate intravascular volume	Ongoing fluid losses (blood or plasma)	Severe pain
Myocardial depression or failure	Cardiac arrhythmias	Cardiac tamponade
Electrolyte imbalances	Acidemia/alkalemia	Hypoglycemia
Glucocorticoid deficiency	Neurological failure	Organ ischemia
Inadequate oxygen carrying ability	Inadequate colloid osmotic pressure	Hypoxemia
Excessive peripheral vasodilation	Excessive peripheral vasoconstriction	Decreased venous return

**Any condition that causes a decrease in albumin concentration will result in decreased COP and intravascular volume retention capabilities.**



## Follow-up

- COP can be measured using a colloid osmometer (wescor.com).<sup>9</sup>
- Normal values reported for plasma COP range from 14–27 mm Hg in dogs and 21–34 mm Hg in cats.
- Normal whole blood COP is reportedly 19.95  $\pm$  2.1 mm Hg in dogs and 24.7  $\pm$  3.7 mm Hg in cats.