CANINE PEDIATRICS:
The Vomiting Puppy

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JP, a 6-week-old, 3.5-kg intact male pit bull mix, presented for anorexia, vomiting, and bloody diarrhea. He had been acquired from a flea market and seemed healthy but thin.

HISTORY

The day after the owners acquired JP, the puppy began vomiting and, the following day, he had diarrhea. On day 4, JP was presented to the primary care veterinarian, who evaluated him for progressive listlessness, anorexia, continued vomiting, and bloody diarrhea.

The owners stated that JP had 2 littermates at the flea market that were not as playful as JP. They also confirmed the puppies had not received any vaccinations.

SNAP Parvo Test (idexx.com) results were positive, and JP was referred to another facility that had an isolation unit and provided 24-hour care.

TABLE 1.
Physical Examination Findings at Referral Facility

BEHAVIOR	
Listlessness	
CARDIAC/RESPIRATORY	
Tachycardia (heart rate, 180 beats/min)	
Tachypnea (respiratory rate, 40 breaths/min), but not dyspneic	
Poor pulse quality	
Pale pink mucous membranes	
BODY CONDITION	
Hypothermia (96°F [35.6°C])	
12% dehydration (marked skin tenting and sunken eyes)	
Cachexia, with a 3/9 body condition score	
PALPATION	
Painful abdominal palpation	
Fluid-filled intestinal loops	

PHYSICAL EXAMINATION

The physical examination findings of JP upon presentation to the referral facility are listed in **Table 1**.

JP also had bloody diarrhea staining his ventral abdomen and hindlimbs. He vomited just after palpation. While JP was able to stand with support, he was extremely weak.

DIAGNOSTIC APPROACH

Peripheral IV access was attempted but, due to JP's volume-depleted state, multiple attempts at cephalic catheterization failed. An 18-gauge, 6-cm catheter was placed into the left jugular vein, allowing a minimal volume of blood to be obtained for analysis of packed cell volume (PCV), total solids (TS), blood urea nitrogen (BUN) (Azostix, usa.healthcare.siemens.com), blood glucose (BG), and blood smear. Fecal flotation was performed on voided stool.

Depending on available resources and the financial limitations of the owners, diagnostics can follow 3 tiers of diagnostic evaluation (see **Levels of Diagnostic Evaluation**).

Initial Analysis

- Initial laboratory tests revealed:
  - BG concentration of 36 mg/dL (pediatric [6- to 8-weeks old] reference interval, 134–272 mg/dL)
  - PCV of 40% (pediatric [6- to 8-weeks old] reference interval, 27%–36%)
  - TS of 4.8 g/dL (pediatric [6- to 8-weeks old] reference interval, 3.9–4.2 g/dL)
  - BUN level of 30 to 40 mg/dL (pediatric [6- to 8-weeks old] reference interval, 14–15.5 mg/dL).
- Blood smear revealed fewer neutrophils than expected, with mild toxic change; this was grossly estimated to be a white blood cell count of 2000 to 3000 (cells/mcL) on 100×

Levels of Diagnostic Evaluation

GOLD

Blood Analysis
- Complete blood count, with smear evaluation
- Serum biochemical profile
- Venous blood gas (eg, acid–base, electrolytes)

Fecal Analysis
- Fecal flotation
- Direct fecal smear
- Parvoviral fecal antigen*

Imaging
- Abdominal radiography/ultrasonography

Other
- Colloid osmotic pressure
- Blood pressure

SILVER

Blood Analysis
- Complete blood count, with smear evaluation
- Serum biochemical profile
- Venous blood gas (eg, acid–base, electrolytes)

Fecal Analysis
- Fecal floatation
- Parvoviral fecal antigen

Other
- Blood pressure

BRONZE

Blood Analysis
- Packed cell volume and total solids
- Blood smear evaluation
- Serum biochemical profile or venous blood gas (eg, acid–base, electrolytes), along with blood glucose and blood urea nitrogen

Fecal Analysis
- Parvoviral fecal antigen

**If result is negative but parvovirus is still suspected, perform polymerase chain reaction on feces.*

magnification. Approximately 10 platelets per high power field were seen on 1000×; this was estimated to be a platelet count of 100,000 to 150,000 (cells/mcL).

- High numbers of *Toxocara canis* eggs were identified in the stool.
- Doppler blood pressure measurement was attempted, but proved difficult due to the small size of the puppy (pediatric [6- to 8-weeks old] reference range, approximately 112 mm Hg).[1]

Further Analysis

After initial treatment, blood was collected in low-volume tubes for routine complete blood count (CBC) and serum biochemical profile (**Table 2,** page 34).

CBC Results

- Marked lymphopenia and neutropenia were seen, typical of parvoviral enteritis.
- Relative hemoconcentration was likely due to severe dehydration. Low PCV due to age and/or anemia due to gastrointestinal (GI) bleeding may become evident after fluid therapy.

Biochemistry Results

- JP's hypoglycemia was more severe than could be attributed to age, cachexia, and decreased food intake.
- Cholesterol is often lower in puppies than adult dogs.
- Electrolyte depletion was attributed to vomiting and diarrhea.
- Low albumin and total protein levels were most likely caused by protein loss through the GI tract, including via GI bleeding.
- Hypocalcemia was at least partially related to severe hypoalbuminemia.
- Increased alkaline phosphatase, bilirubin, and phosphorus were most likely related to a combination of age and illness.

DIAGNOSIS

Cormorbidities

In this patient, canine parvovirus infection had been diagnosed before referral. Additional comorbid conditions may include infection with another virus (eg, coronavirus), intestinal parasitism, intestinal bacterial infection or overgrowth (eg, *Escherichia coli*, *Salmonella* species, *Campylobacter* species, *Clostridia* species), intussusception, or foreign body.

Sepsis & Hypovolemic Shock

The presence of hypovolemic shock and sepsis—caused by dehydration, leukopenia, and intestinal bacterial translocation—is the most life-threatening condition present in JP. Associated hypoglycemia, hypoalbuminemia, and electrolyte or acid–base disturbances must be addressed.

TABLE 2.
Clinicopathologic Results[2-5]

VARIABLE	RESULT	ADULT REFERENCE INTERVAL	PEDIATRIC (6–8 WEEKS OF AGE) INTERVAL
Complete Blood Count			
Red blood cell count (× 10^6/L)	5.06	5.34-8.5	4.3-5.1
Hemoglobin (g/dL)	13	12.3-19.7	8.5-11.3
Hematocrit (%)	40	37-57	26.5-35.5
Mean corpuscular volume (fL)	60	59-76	63.2-74.3[a]
Mean corpuscular hemoglobin (pg)	23	20.7-25.6	23-25.5[a]
Mean corpuscular hemoglobin concentration (g/dL)	33.2	32-36.4	31.4-35
Platelet count (× 10^3/L)	136,000	200-500	> 150,000
White blood cell count (× 10^3/L)	2.6	4.53-14.99	12.6-26.7
Segmented neutrophils (× 10^3/L)	1.82	2.27-10.14	4.2-17.6
Band neutrophils (× 10^3/L)	0.26	0-0.26	0-0.3
Lymphocytes (× 10^3/L)	0.52	0.76-4.23	2.8-16.6
Monocytes (× 10^3/L)	0.15	0.15-1.35	0.5-2.7
Eosinophils (× 10^3/L)	0	0.08-1.1	0.1-1.9
Basophils (× 10^3/L)	0	0-0.15	0
Reticulocytes (%)	0.4	n/a	2.6-6.2
Serum Biochemical Profile			
Glucose (mg/dL)	86[b]	81-133	134-272
Blood urea nitrogen (mg/dL)	33	8-28	14-15.5
Creatinine (mg/dL)	1	0.6-1.6	0.6-1.6
Sodium (mEq/L)	136	143-152	143-152
Potassium (mEq/L)	3.1	3.4-4.9	3.4-4.9
Chloride (mEq/L)	106	108-117	108-117
Bicarbonate (mEq/L)	18	18-26	18-26
Anion gap (mEq/L)	3	13-22	n/a[c]
Albumin (g/dL)	1.9	2.9-4	2.1-2.7
Plasma protein (g/dL)	4.8	6-8	6-8
Total protein (g/dL)	3.2	5.2-7.4	3.9-4.8
Calcium (mg/dL)	8	9.2-11.3	9.2-11.3
Phosphorus (mg/dL)	5.7	2-5	8.7-11.5
Cholesterol (mg/dL)	137	133-338	111-258
Total bilirubin (mg/dL)	0.4	0.1-0.4	0.1-0.2
Alanine aminotransferase (U/L)	48	9-58	9-24
Alkaline phosphatase (U/L)	178	5-129	144-177
Gamma-glutamyltransferase (U/L)	< 3	0-5	0-7
Creatine kinase (U/L)	267	10-274	10-274
Colloid osmotic pressure (mm Hg)	12	21-25	< 18

a. Values are for 4-week-old puppies rather than 6- to 8-week-old puppies
b. After glucose bolus upon admission
c. No published data available on reference interval for this variable in pediatric patients

Should Oxygen Be Given During Initial Resuscitation?

While JP was tachypneic—likely secondary to hypovolemia—he was not dyspneic and his lung sounds were clear. Therefore, supplemental oxygen was probably not necessary but could have been provided until normoxemia was confirmed. However, for a neonate (< 2 weeks of age), oxygen therapy would be recommended.

Fluid Therapy Plan

1. Expand intravascular volume and treat shock with IV bolus of fluids; JP received a 120-mL bolus (30 mL/kg). Volume resuscitate the patient appropriately based on clinical signs of improved:
   - Pulse quality
   - Heart rate
   - Mentation
   - General perfusion parameters.
2. Correct estimated dehydration: JP's estimated dehydration was 12%. The remaining deficit was corrected over 12 H.
   - 3.5 kg (body weight) × 0.12 (dehydration) = 420 mL fluid deficit
   - 420 mL (original deficit before fluid bolus) – 120-mL bolus fluid volume = 300 mL
   - 300 mL (remaining deficit)/12 H = **25 mL/H**
3. Provide for estimated ongoing loss: JP had frequent diarrhea and vomiting, with an estimated loss of 75 mL Q 24 H; therefore, 75 mL/24 H = **3.1 mL/H**
4. Provide maintenance fluids; fluid requirements for puppies vary with age (**Table 3**).[6,7] For JP, fluid requirements were:
   - 3.5 kg (body weight) × 80 mL Q 24 H = 280 mL Q 24 H
   - 280 mL /24 H = **11.7 mL/H**
5. Consider colloidal support (see **Table 2**):
   - VetStarch (abbottanimalhealth.com): 2 mL/kg/H
   - 3.5 kg (body weight) × 2 mL/kg/H = **7 mL/H**

TABLE 3.
Maintenance Fluid Requirements for Puppies[6,7]

AGE	FLUID REQUIREMENT
Neonates (0–2 weeks)	120–180 mL/kg Q 24 H
Pediatric patients (3–6 weeks)	80–100 mL/kg Q 24 H
Puppies (7 weeks–1 year of age)	60 mL/kg Q 24 H

Crystalloid fluid rate for the first 12 hours—after the initial fluid bolus—was calculated by considering:

Replacement (25 mL/H) + ongoing losses (3.1 mL/H) + maintenance (11.7 mL/H) = **39.8 mL/H**

Colloid volume was subtracted (39.8 mL/H – 7 mL/H), which equaled a crystalloid fluid rate of **33 mL/H**.

During the remaining period of hospitalization, and after the dehydration deficit had been replaced, fluid rate was decreased to reflect only maintenance needs and ongoing losses.

TREATMENT APPROACH

Therapy for Hypovolemic Shock

- Due to the life-threatening hypoglycemia, JP received an initial IV bolus of 0.5 g/kg dextrose (3 mL of 50% dextrose diluted in 7 mL of 0.9% saline over 1 minute).
- Aggressive fluid therapy was indicated due to the extreme dehydration and hypovolemic shock (see **Fluid Therapy Plan**).
- A bolus of 120 mL (34 mL/kg) of warmed lactated Ringer's solution was administered over 15 minutes, followed by 33 mL/H (10 mL/kg/H) of lactated Ringer's solution with 5% dextrose and potassium chloride supplementation.
- A colloid was administered in addition to the crystalloid.

BG was measured every 6 H, with glucose supplementation adjusted as necessary to maintain normoglycemia.

Therapy for Parvovirus & Sepsis

JP was treated with symptomatic and supportive care (see **Typical Supportive Therapies for Parvoviral Enteritis**), including provision of warmth and zinc oxide barrier therapy to prevent moist dermatitis.

Due to sepsis secondary to leukopenia, antibiotic therapy was initiated (IV initially; then PO once

Typical Supportive Therapies for Parvoviral Enteritis

- **Crystalloid fluids**, along with **dextrose** and **potassium chloride** supplementation as needed
- **Colloidal support**, such as VetStarch, hetastarch, or plasma
- **Antiemetics**, such as maropitant, dolasetron, or metoclopramide
- **Gastric protectants**, such as famotidine or pantoprazole
- **Parenteral antibiotic therapy** while hospitalized (eg, ampicillin/sulbactam, cefoxitin)
- **Antidiarrheals**, such as probiotics or metronidazole
- **Analgesics**, such as buprenorphine and lidocaine
- **Nutritional support**, such as nasogastric tube feeding (if oral feeding refused) or mirtazapine

TABLE 4.
Supportive Therapy for JP

THERAPY TYPE	MEDICATION/DIET	DOSAGE
Antiemetic	Maropitant	1 mg/kg SC or IV Q 24 H
Gastroprotectant	Famotidine	0.5 mg/kg IV Q 12 H
Antibiotic	Ampicillin/sulbactam	25 mg/kg IV Q 8 H
Antidiarrheal	Probiotics	Dependent on probiotic chosen
Analgesics	Buprenorphine	0.02 mg/kg IV Q 8 H PRN
	Lidocaine	20 mcg/kg/min IV CRI
Nutrition	Clinicare (abbottanimalhealth.com)	RER/24 H = mLs of Clinicare per H via nasogastric tube

CRI = constant rate infusion; PRN = as needed; RER = resting energy requirement

TABLE 5.
Daily Monitoring Recommended for Parvovirus Patients

THERAPY	SPECIFICS	FREQUENCY[a]
Physical examination	Temperature, heart rate, respiratory rate, lung auscultation, pulse quality, mucous membrane color, capillary refill time, abdominal pain, urine output	Q 4 to 6 H[b]
Monitoring	Packed cell volume, total solids, blood glucose	Q 6 to 8 H[b]
Blood monitoring	Electrolytes, especially potassium	Q 24 H
Blood pressure		Q 6 to 8 H[b]
Pulse oximetry		Dependent on clinical signs
Nursing care & barrier treatment	For example, zinc oxide	Q 2 H, depending on severity of diarrhea
Nutritional evaluation	Gastric residual volume, tolerance of nasoesophageal or nasogastric tube feeding	Q 2 to 4 H

a. Dependent on severity of clinical signs
b. These parameters may need to be monitored more frequently, even Q 1 H, in some very critical or dynamic patients.

vomiting abated). A potent antiemetic was initiated to treat nausea and minimize risk for aspiration pneumonia.

The supportive medications and nutrition JP received are outlined in **Table 4**; daily in-hospital monitoring for parvovirus patients is described in **Table 5**.

Ongoing Supportive Care

JP's vital parameters improved markedly over the first few hours of therapy. By the following day, he subjectively looked less nauseated and had less abdominal pain. A temporary nasogastric feeding tube was placed at that time for nutritional support, with sporadic gastric suctioning to measure

Other Therapeutic Options: Worth It?

In the past, fresh or fresh frozen plasma from recovered dogs had been suggested to provide antiparvoviral antibodies. Recent studies, however, have demonstrated no beneficial effect of this method and shown that even recently recovered animals have minimal anti-canine parvovirus antibody concentrations.[8,9] Moreover, such treatment may prime the dog for future transfusion reactions later in life.

Equine endotoxin antiserum, recombinant human granulocyte-stimulating factor, and antiviral agents (eg, oseltamivir) have not been shown to improve survival or outcome.[10-12] In small studies, use of feline interferon has been weakly associated with improved survival; however, this agent is not readily available in veterinary hospitals in the U.S.[13,14]

residual gastric volume. By day 4, JP was ingesting small amounts of meat-based baby food, and the nasogastric tube was removed. JP was dewormed with fenbendazole and discharged later that day.

PROGNOSIS

JP was discharged on day 4, and the owner was taught how to administer medications and encourage JP to eat. The primary care veterinarian performed a recheck examination 3 days later, and reported that JP was acting and eating normally at that time.

The prognosis for canine parvovirus infection is fair to good. Perhaps surprisingly, severity of neutropenia is *not* a negative prognostic factor; rather, severity of dehydration and lymphopenia may be instead.[15] Recently, several studies have evaluated other measures that may affect prognosis.[16-18]

A study from Colorado State University compared standard in-hospital treatment versus a modified outpatient treatment (using volume resuscitation followed by SC fluid therapy and supportive care), with recent survival rates of 80% to 90% reported with treatment.[19] Both protocols can be successful, with a slightly lower survival rate in outpatients.[19]

Hospitalization with intensive therapy was initially indicated for JP due to his severe hypoglycemia, dehydration, and shock, but a modified outpatient protocol (SC fluids, antiemetics, antibiotics) may be a good alternative for less severely affected patients or clients with financial limitations.

IN SUMMARY

Although there are differences between young and adult animals, pediatric patients can still be treated aggressively and respond well to therapy. However, clinicians must be aware of their normal physiologic and hemodynamic measures. The small size of these patients should not limit our ability to appropriately treat them.

BG = blood glucose; BUN = blood urea nitrogen; CBC = complete blood count; GI = gastrointestinal; PCV = packed cell volume; TS = total solids

Key Points: Treating the Pediatric Patient

In critically ill neonate and pediatric patients, **goals of treatment** should be prioritized by the four H's:

- Hypovolemia/hydration
- Hypothermia
- Hypoglycemia
- Hypoxemia

FLUID THERAPY

- Dehydration can rapidly progress to hypovolemia in neonates and pediatric patients; therefore, aggressive fluid therapy is warranted because these small patients can deteriorate quickly.
- Fluid requirements for neonates and pediatric patients are much higher than those for adults.
- In critically ill pediatric patients, fluid therapy for shock must initially be given by IV or intraosseous routes.[6,7] Intraperitoneal or SC routes are not adequate due to slower absorption and, ideally, should not be used in the critically ill, dehydrated, or hypovolemic patient.
- Colloids can be used in pediatric patients; however, keep in mind that puppies have a lower colloid osmotic pressure than adult dogs.[20] If necessary, a colloid (eg, hetastarch, 1 mL/kg/H; VetStarch, 2 mL/kg/H) can be used to keep colloid osmotic pressure above 15 mm Hg. No published data are available on colloid use in neonates.

TEMPERATURE

- Normal rectal temperature in neonates is 96°F ± 1.5°F (35.6°C ± 0.7°C) in the first week of life; then 98.6°F to 100°F (37°C to 38.2°C) in the second and third weeks of life.[21]
- Adult temperatures are reached by 7 weeks of age.[21]
- Careful warming should be initiated to prevent overheating.

HYPOGLYCEMIA

- Neonates and pediatric patients are prone to hypoglycemia due to decreased glycogen stores, inefficient hepatic gluconeogenesis, and an immature glucose feedback mechanism.
- Hypoglycemia is worsened by anorexia, ongoing losses (eg, vomiting, diarrhea), dehydration, and sepsis.
- Frequent BG monitoring is warranted in these patients; however, the minimum amount of blood should be drawn to prevent iatrogenic anemia.

IMMUNE SYSTEM

- In neonate and pediatric patients, the immune system is not fully mature until 3 to 6 months.
- Poor husbandry (eg, lack of vaccination, lack of parasite prevention) often worsens clinical disease.

Pathophysiology of Parvovirus

Canine parvovirus (CPV) is a common and severe pathogen that affects young dogs that are unvaccinated, under-vaccinated, or immunosuppressed. The virus first emerged in dogs in the mid 1970s and has since mutated into 3 different forms: CPV-2a, CPV-2b, and, most recently, CPV-2c.

All 3 forms of CPV are environmentally stable, nonenveloped viruses transmitted via the fecal–oral route.

- The virus initially replicates in oropharyngeal lymphoid tissues, leading to viremia; rapidly dividing cells of the GI tract, thymus, lymph nodes, and bone marrow are most affected.
- Loss of both intestinal epithelial villous and crypt cells leads to malabsorption and increased intestinal permeability, accompanied by vomiting, diarrhea, and GI bleeding.
- Destruction of bone marrow cells results in neutropenia and, to a lesser degree, thrombocytopenia.
- Translocation of intestinal bacteria, complicated by neutropenia, often leads to bacteremia, endotoxemia, and sepsis.

Without treatment, CPV can be life threatening due to sepsis, severe fluid losses and electrolyte derangements secondary to anorexia, vomiting, and diarrhea. In order to ensure the best outcome, treatment should be aimed toward symptomatic supportive care, aggressive fluid therapy, antiemetics, antibiotic therapy, and nutritional support.

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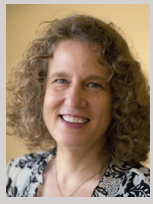

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