Canine parvovirus (CPV) is a common pathogen affecting young dogs that are unvaccinated, under-vaccinated, or immunosuppressed. Without treatment, CPV can be life threatening due to severe fluid losses and electrolyte derangements secondary to anorexia, vomiting, and diarrhea. In order to ensure the best outcome, treatment should be aimed towards symptomatic supportive care, aggressive fluid therapy, anti-emetics, antibiotic therapy, and nutritional support. This lecture will review the etiology, clinical signs, treatment, overall prognosis and preventative measures for CPV.

**ETIOLOGY**
CPV was originally discovered in 1967 and resulted in mild diarrhea. Since then, the virus has evolved to CPV-2 in 1978, with additional evolution of subtypes CPV-2a, CPV-2b, and more recently, CPV-2c. CPV-2b is thought to be more pathogenic and has replaced CPV-2a as the cause of parvovirus throughout the United States.

**PATHOGENESIS**
CPV is a small, single-stranded, non-enveloped DNA virus that preferentially infects rapidly diving cells (e.g., bone marrow, gastrointestinal tract, myocardium, etc.). There is an increased prevalence during warm summer months (e.g., July through September). Spread occurs via ingestion of bodily fluids (e.g., vomitus, diarrhea, etc.) containing the virus. CPV replicates quickly and infects the intestinal crypt epithelium by day 4 of infection. Clinical signs are thought to appear within 4-10 days of exposure, while antibody development occurs approximately 5 days after exposure.

**RISK FACTORS/SIGNALMENT**
Parvovirus is often seen in more urban environments with affected pups coming from poor husbandry backgrounds. As a result, pet owners may also have financial limitations. Dogs affected typically are < 6 months of age, between 6 to 20 weeks of age. Typically, there is no gender predilection, although one study reported that in dogs > 6 months of age, intact, male dogs were overrepresented. Certain breeds are thought to be at increased risk:

- American Pit Bull terrier
- Rottweilers
- German Shepherd dogs
- Doberman pinschers

In studies, breed, age, gender, and body weight did not appear to correlate with outcome or duration of hospitalization in one study.
CLINICAL SIGNS
Clinical signs seen with parvovirus include:

- Anorexia
- Lethargy/Listlessness
- Malaise
- Hypersalivation (e.g., secondary to nausea)
- Vomiting
- Abdominal pain
- Diarrhea*
- Hematochezia

In mild cases, diarrhea may not be seen.²

PHYSICAL EXAMINATION FINDINGS
Classic physical examination findings for the parvovirus patient include:

- Dehydration (e.g., prolonged skin tenting, sunken eyes, etc.)
- Cachexia
- Hypothermia
- Fever
- Tachycardia
- Tachypnea
- Pallor
- Prolonged capillary refill time (CRT)
- Hypersalivation
- Poor pulse quality
- Hypovolemic shock
- Fluid filled loops of intestine
- Malodorous diarrhea staining
- Dyspnea
- Death

DIFFERENTIAL DIAGNOSES:
Other rule outs for patients exhibiting similar clinical signs include:

- Other viral (e.g., coronavirus) infections
- Other bacterial (e.g., E. coli) infections
- Parasitism
- Intestinal bacterial infection (e.g., Salmonella, Campylobacter)
- Intussusception
- Foreign body obstruction
**DIAGNOSTIC TESTING**

The use of a fecal antigen ELISA test is the most rapid, cost-effective way of diagnosing CPV for the practitioner. The fecal antigen ELISA is sensitive to detect both CPV-2b and CPV-2c.\(^6\) Other tests that can be considered include PCR, virus isolation, and hemagglutination inhibition, but these are less commonly performed. That said, in a dog that tests negative on an in-house fecal antigen ELISA test, a PCR (on feces) can be considered due to its high sensitive. A real-time PCR can improve the sensitivity and specificity, and allows for rapid detection of CPV-2.\(^7\)

The diagnosis of CPV can be more challenging if these diagnostic tests are not readily available, as the decision to put an immunocomprised, young, immunologically naïve puppy into isolation poses large risk if the patient truly does not have CPV. Note that the modified live (ML) vaccine for CPV also replicates in the mucosal epithelium of the GIT; theoretically, the presence of low levels of antigen can be detected by various tests, resulting in a false-positive result.\(^2\) However, a recent study showed that various types of ML CPV-2 vaccines did not produce levels of antigen that were detectable on a SNAP ELISA parvovirus antigen test within 7 days of vaccine.\(^2,8\)

Depending on the financial limitations of pet owners, the ideal “gold” standard for the parvovirus patient includes:

**Gold or Cadillac™ Standard:**
- Parvoviral fecal antigen test
- Complete blood count + blood smear
- Biochemistry panel
- Venous blood gas (e.g., acid-base status, electrolytes)
- Fecal float/smear
- PCV/TS/BG/AZO
- Blood pressure
- PCR if negative fecal antigen test and still suspicious
- Abdominal radiographs
- Colloid oncotic pressure (COP)
- + abdominal ultrasound (if intussusception is suspected)

**Silver or Honda™ Standard:**
- Parvoviral fecal antigen test
- CBC with smear evaluation
- Biochemistry panel or venous blood gas
- Fecal float
- Blood pressure

**Bronze or Yugo™ Standard:**
- Parvoviral fecal antigen
- Blood smear + PCV/TS/BG/AZO
- Venous blood gas with electrolytes
CLINICOPATHOLOGIC FINDINGS
As parvovirus affects the pediatric patient, blood work changes associated with young patients are observed (e.g., isosthenuria, mild anemia, hypoproteinemia, elevated alkaline phosphatase, hyperphosphatemia, etc.). Additional clinicopathologic findings seen with parvovirus include:

- Lymphopenia
- Neutropenia
- Overall leukopenia
- Left shift
- Hypoglycemia
- Hemoconcentration (for a puppy)
- Hypoalbuminemia
- Hypoproteinemia
- Elevated liver enzymes
- Electrolyte abnormalities (e.g., hyponatremia, hypokalemia, hypochloremia)
- Mildly increased blood urea nitrogen
- Thrombocytopenia (due to consumption/blood loss into the GIT or DIC)
- Prolongation of PT/PTT
- Acid-base abnormalities (e.g., metabolic acidosis)
- Azotemia (secondary to multi-organ dysfunction)

GOALS
Treatment of the canine parvovirus patient is aimed towards fluid therapy, antibiotic therapy, nutritional support, gastrointestinal support, supportive care, and monitoring. Specific goals of pediatric medicine include temperature control, fluid therapy, nutritional support (with the goal of weight gain), and control of infectious disease and parasites. In the more critically ill pediatric patient, goals should be focused on the following 4H’s: Hypovolemia/Hydration, Hypothermia, Hypoglycemia, and Hypoxemia.

Hypovolemia/Hydration: One of the most common causes of neonatal hypovolemic shock is dehydration, which can occur quickly in these small patients due to gastrointestinal losses or higher fluid requirements; therefore, aggressive fluid therapy is warranted because these small patients can deteriorate quickly. For neonates, maintenance fluid requirements are 120-180 ml/kg/day, while for pediatric patients, fluid requirements range from 60-100 ml/kg/day. In critically ill pediatric patients, fluid therapy for shock must initially be given by IV (or intraosseous) route. Intraperitoneal or SQ routes are not adequate due to slower absorption and, ideally, should not be used in the critically ill, dehydrated, or hypovolemic patient. In severely dehydrated or hypovolemic patients, initial shock doses of a balanced crystalloid such as 30-45 ml/kg should be used. Serial assessment should be done after the bolus to reassess response and to evaluate the need for further fluid resuscitation. Potassium and dextrose supplementation typically is required, and careful monitoring of blood glucose and electrolytes is warranted. Lastly, colloids can be used in pediatric patients; however, keep in mind that puppies have a lower colloid osmotic pressure (COP) than adult dogs. If necessary, a colloid (e.g., Hetastarch, 1 mL/kg/H; VetStarch, 2 mL/kg/H) can be used to keep colloid osmotic pressure above 15 mm Hg.
Hypothermia: In pediatric patients, careful temperature regulation and awareness of normal homeostatic temperatures is imperative. Normal rectal temperature in the first week of life is $96^\circ \pm 1.5^\circ F$ ($35.6^\circ \pm 0.7^\circ C$), $98.6^\circ - 100^\circ F$ ($37-38.2^\circ C$) in the second and third week of life, and by 7 weeks of age, reach normal adult levels. Hypothermia can lead to bradycardia and intestinal ileus.

Hypoglycemia: Young patients are prone to hypoglycemia, which can be aggravated by anorexia, vomiting, diarrhea, dehydration, and infection. Ideally, IV dextrose boluses should be used (0.5-1.0 g/kg or 0.5-1.5 ml/kg IV of 50% dextrose, diluted 1:2-1:3) preferentially over oral dextrose. Isotonic fluids supplemented with 2.5-5% dextrose as a CRI can also be used (i.e., not D5W); however, caution should be used to prevent over-supplementation as prolonged hyperglycemic can result in worsening of dehydration via osmotic diuresis (due to puppies having insulin insensitivity).

Hypoxemia: Young patients exhibiting clinical signs of hypoxemia (e.g., cyanosis, orthopnea, tachypnea, dyspnea, and abnormal auscultation) should be immediately treated with oxygen therapy. Because neonates and pediatric patients are “normally anemic,” it may be clinically more difficult to “see” cyanosis since detection of cyanosis is dependent on hemoglobin concentration. In dyspneic patients, initial first line therapy should include oxygen therapy via facemask, oxygen cage, incubator, or endotracheal tube. The FiO$_2$ should not exceed 40-60% for more than a brief period due to the risk of oxygen toxicity.

Antibody therapy
In general, beta lactam antimicrobials are considered the safest choices in young, growing puppies. If possible, avoid chloramphenicol, aminoglycosides, tetracyclines, and drugs like clindamycin that undergo enterohepatic cycling. Metronidazole can be used, but dose interval should be prolonged. Finally, quinolones have been shown to result in cartilage lesions in puppies and should be used only with the benefit outweighs the risk and ideally avoided altogether in growing, large breed dogs. Commonly recommended dosages include:

- Amoxicillin 6-20 mg/kg IV, PO q. 12
- Amoxicillin + clavulanic acid 12.5-25 mg/kg PO q. 12
- Cephalexin/Cefazolin 10-30 mg/kg IV q. 8-12
- Cefoxitin 22 mg/kg IV q. 8
- Ampicillin 22 mg/kg IV q. 8
- Ampicillin/Sulbactam 22-30 mg/kg IV q. 8

Gastrointestinal support
Anti-emetics (e.g., maropitant, ondansetron, dolasetron) should be implemented for patient comfort and to treat nausea.

Anti-emetics:
- Maropitant: 1 mg/kg SQ or IV q. 24 hours
- Ondansetron: 0.1-0.2 mg/kg IV q. 8-12 hours
- Dolasetron: 0.5-1 mg/kg SQ, IV q. 24 hours
- Metoclopramide: 0.1-0.5 mg/kg SC, IV q. 8 hours or 1-2 mg/kg/day as CRI IV
The use of gastric pH-altering medication is not necessarily warranted in the CPV patient; most are unlikely to have gastric ulcers. As these gastric pH-altering medications have no anti-emetic effect, the author believes these are not typically necessary. That said, therapeutic doses include:

H₂ blockers:
- Famotidine: 0.5-1 mg/kg IV, SQ q. 12-24 (least p-450)
- Ranitidine: 0.5-2 mg/kg, IV, PO, SQ q. 8-12 (moderate p-450)
- Cimetidine: 5-10 mg/kg IV, PO, SQ q. 6-8 (most p-450)

Proton-pump inhibitors:
- Omeprazole: 0.5-1 mg/kg PO q. 24 hours
- Pantoprazole: 1 mg/kg IV q. 24 hours

MISCELLANEOUS THERAPIES
Fresh or fresh frozen plasma from recovered dogs has been suggested in the past to provide anti-parvoviral antibodies, but recent studies have not found a beneficial effect and have found that even recently recovered animals have minimal anti-CPV antibody concentrations.¹¹³ Moreover, such treatment may prime the dog for future transfusion reaction at a later point in its life. Equine endotoxin antiserum, recombinant human granulocyte-stimulating factor (rhG-CSF), or anti-virals (e.g., Tamiflu) have not been shown to be effective in improving survival or outcome.¹⁴-¹⁶ In small studies, the use of feline interferon has been weakly associated with improved survival; however, this is not readily available in veterinary hospitals.¹⁷,¹⁸

PROGNOSIS
The prognosis for canine parvovirus infection is fair to good with treatment, with recent reports of 80-90% survival with various modalities of treatment.⁸ Perhaps surprisingly, severity of neutropenia is not a negative prognostic factor, but severity of dehydration and lymphopenia may be.¹⁹ Recently, studies have compared standard in-hospital treatment versus a modified outpatient treatment (using volume resuscitation followed by subcutaneous fluid therapy and supportive care). Both protocols can be successful, with a survival only slightly lower in outpatients.⁸ A modified outpatient protocol may be a good alternative for less severely affected cases or those with financial limitations.

INFECTIOUS RISKS
In animals developing acute parvovirus, caution must be taken to prevent further spread. The use of appropriate hygiene (including protective eye ware, gowns, gloves, etc.) should be used when handling the patient and bodily fluids while hospitalized. A 10% bleach solution, iodine-based disinfectant, accelerated hydrogen peroxide, or quaternary ammonium solution can all be used against parvovirus.² Pet owners should be made aware to quarantine all affected pets for several weeks and to avoid dog parks, doggy daycares, training schools, city parks, etc. until the puppy is no longer at risk for shedding virus.

PREVENTION
While vaccination against parvovirus is highly effective, failure of passive transfer, early weaning, lack of vaccination, inappropriate client education (e.g., frequency of veterinary visits), or maternal antibody interference can result in disease. Parvovirus can be easily prevented by
appropriate client education and vaccination. As DHPP is considered a core vaccine, puppies should be vaccinated frequently while maternal antibodies are waning. In high-risk areas (e.g., shelters), a vaccine every 2 weeks is indicated until 16-22 weeks of age (depending on if the breed is at risk) to prevent outbreaks.

ABBREVIATIONS
AZOSTICK = BUN, bpm = beats per minute, BPM = breaths per minute, BG = blood glucose, HR = heart rate, IO = intraosseous, IP = intraperitoneal, IV = intravenous, PCV = packed cell volume, SQ = subcutaneous, TS = total solids

FOOTNOTES:

REFERENCES

NOTE: When in doubt, all drug dosages should be confirmed and cross-referenced with a reference guide such as Plumb’s Veterinary Drug Handbook.