A n elevation in red blood cell (RBC) mass is defined as polycythemia or erythrocytosis and can be diagnosed by an increase in packed cell volume (PCV), RBC count, or hemoglobin concentration or an elevated hematocrit (Hct) percentage. Polycythemia can be categorized as relative polycythemia (an elevated RBC count with a normal RBC mass secondary to loss of plasma fluid volume from dehydration) or absolute polycythemia (an elevated RBC count and increased RBC mass in the absence of dehydration). Most commonly, an elevation in Hct is caused by dehydration or severe fluid shifts. After questioning the client, clinical signs of anorexia, polyuria and polydipsia, and vomiting and diarrhea may suggest that dehydration is present. Relative polycythemia is diagnosed by assessing the hydration status of the patient as well as assessing laboratory findings for dehydration (e.g., elevated plasma protein [PP], elevated blood urea nitrogen [BUN], and increased urine specific gravity). If the patient is well hydrated, a diagnosis of absolute polycythemia should be considered. If the hydration status of the patient is unclear, a fluid challenge may be performed.

Absolute polycythemia can be divided into primary and secondary causes. Primary absolute polycythemia is a monoclonal myeloproliferative disorder in which erythroid precursors multiply independently of erythropoietin signaling and mature into normal RBCs in excessive numbers. Secondary absolute polycythemia is excessive RBC production in response to erythropoietin signaling. This form of polycythemia can be further divided into appropriate causes secondary to hypoxia and inappropriate causes in which hypoxia is not present. In either case, however, erythropoietin production occurs in excess. Figure 1 provides a concise overview of the breakdown of the types of polycythemia.

Primary polycythemia was formerly referred to as polycythemia vera, a term derived from human medicine. Several differences between the disease that affects people and the one that affects animals make this correlation invalid. In human medicine, additional laboratory criteria for polycythemia vera include thrombocytosis and leukocytosis. Also, clinical findings can include hepatomegaly, hypertension, and hyperuricemia, which are not common findings among veterinary patients. Because of these additional clinical findings in people with polycythemia vera, the use of the terms primary polycythemia and primary erythrocytosis has been adopted in veterinary medicine.

Many of the clinical signs associated with polycythemia are related to hyperviscosity created by the increased RBC mass in circulation. The increased RBC mass causes a reduction in blood flow through vessels, leading to engorged vessels and tissue hypoxia caused by decreased oxygen delivery. This ultimately leads to neurologic signs along with polyuria and polydipsia as well as an increased risk of thrombocytosis and leukocytosis.
well as bleeding. Emergency treatment is necessary to relieve the life-threatening consequences of hyperviscosity.

**DIAGNOSTIC CRITERIA**

**Historical Information**

**Gender Predisposition**

For all four categories of polycythemia, there is no apparent gender predisposition.

**Age Predisposition**

- **Relative polycythemia:** No apparent age predisposition; this is dependent on the underlying disorder causing dehydration or fluid shift.
- **Primary absolute polycythemia:** Predominantly middle-aged animals.
- **Appropriate secondary absolute polycythemia:** Dogs and cats with congenital cardiac diseases, especially those associated with right-to-left shunting of blood, are most likely to be diagnosed at a young age. Other less common causes of hypoxia do not have an obvious age predisposition.
- **Inappropriate secondary absolute polycythemia:** Predominantly middle-aged to older animals.

**Breed Predisposition**

Dachshunds and greyhounds have been found to have an Hct that is higher than the normal range for most dogs. This is normal for them, and no clinical signs are present.

- **Appropriate secondary absolute polycythemia:** Keeshonden, bulldogs, beagles, and Samoyeds are predisposed to inheriting tetralogy of Fallot. Other breed predispositions are not reported for congenital cardiac shunt abnormalities that lead to hypoxia and polycythemia. Breeds predisposed to various lung diseases are reported but rare, and a comprehensive list is beyond the scope of this article.

**Owner Observations**

- **Relative Polycythemia**
  - Decreased water intake.
  - Excessive fluid loss (e.g., vomiting, diarrhea, polyuria and polydipsia).
- **Primary Absolute Polycythemia**
  - Signs are often a consequence of hyperviscosity in which the increased RBC mass causes decreased blood flow and distention of vessels.
  - Nervous system disturbances, including mentation changes (e.g., lethargy, dementia), hind limb weakness, ataxia, blindness, and seizures.
  - Episodic bleeding (e.g., epistaxis, hematuria, hematochezia, hematemesis).
  - Erythema of skin and mucous membranes.
  - Increased water consumption and urination.

**KEY TO COSTS**

- $ indicates relative costs of any diagnostic and treatment regimens listed.
- $ costs less than $250
- $$ costs between $250 and $500
- $$$ costs between $500 and $1,000
-$$$$ costs more than $1,000
Appropriate and Inappropriate Secondary Absolute Polycythemia

- Signs of underlying heart or lung disease predominate. These patients are usually cyanotic and dyspneic. Even though the stimulus for RBC production is appropriate, the response of the bone marrow may be excessive, leading to signs of hyperviscosity.
- Clinical signs as noted with primary absolute polycythemia may also be observed.

Other Historical Considerations/Predispositions

- For both primary and secondary absolute polycythemia, the onset of clinical signs is usually gradual; owners may only note minimal changes in attitude or demeanor.
- Patients may be presented with an acute history of bleeding disorders, seizures, or other neurologic signs.

Physical Examination Findings

Relative Polycythemia

- Clinical signs are typically attributed to the underlying disorder causing dehydration or fluid shift.
- Tacky and/or hyperemic mucous membranes, decreased skin turgor, or other findings consistent with dehydration.
- Pleural or abdominal effusion.
- Severe vomiting or diarrhea, as is seen with diseases such as hemorrhagic gastroenteritis.

Absolute Polycythemia

- Peripheral edema: Ulcerative skin disease, skin sloughing secondary to burns.

Primary Absolute Polycythemia

Physical examination findings are variable and may include one, several, or all of the findings described below and occur secondary to hyperviscosity.

- Fundic examination: Engorged retinal vessels with possible hemorrhages.
- Neurologic examination: Dullness, stupor, ataxia, seizures, postictal state.
- Rectal examination: Evidence of melena or hematochezia.
- Evidence of previous or active epistaxis.
- Hyperemic mucous membranes and skin.
- Polyuria and polydipsia.
- Splenomegaly.

Appropriate and Inappropriate Secondary Absolute Polycythemia

- Findings related to hyperviscosity as discussed above.
- Elevated respiratory rate or presence of a cough.
- Depending on the location of a cardiac shunt, a murmur may be auscultated.

Laboratory Findings

Complete Blood Count $ 

- For all categories, elevations in PCV, RBC count, and Hct are observed. Hct above 50% in cats or
C H E C K P O I N T S

- It is debatable whether one should use phlebotomy alone or hydroxyurea alone after initial phlebotomy, thus reserving phlebotomy as an emergency treatment. Phlebotomy is the first line of treatment because it reduces the number of RBCs in a short period of time. Hydroxyurea works to maintain a lower RBC count by limiting new RBC production. Using hydroxyurea as the sole therapy delays the reduction in Hct by up to 2 to 3 months when taking into account that RBCs typically survive in circulation for 120 days in dogs and for 70 days in cats. Ultimately, the first step in stabilizing a polycythemic patient is phlebotomy, and long-term management is chosen based on patient progress and owner compliance, as well as the owner’s financial stability and willingness to return to the hospital.

- Bone marrow aspirate or biopsy is not beneficial in differentiating between primary and secondary polycythemia; however, it may be helpful in detecting underlying bone marrow disorders, such as neoplasia, as well as in establishing a baseline for future monitoring.

- In humans, a familial disorder involving a genetic mutation of the erythropoietin receptor has also been described; however, this has not been documented in animals.

- In some large dogs, splenic contraction can cause a mild relative erythrocytosis. This can be seen secondary to stress, strenuous exercise, or severe pain.

above 55% in dogs is consistent with polycythemia. Signs may be seen at this level; however, Hct above 65% to 70% more commonly arises in the clinical signs described above.

- In relative polycythemia, PP is increased because of loss of plasma volume; in the remaining categories, it is likely to be within normal range.

Chemistry Profile

- Relative polycythemia: A relative increase in albumin may be seen along with a prerenal azotemia. Depending on the underlying disease process resulting in dehydration, other biochemical abnormalities may be noted.

- Primary absolute polycythemia: Rarely, hypoglycemia may be noted because of increased glucose utilization and hepatic glycogen depletion secondary to increased RBC mass.

- Appropriate secondary absolute polycythemia: Normal to increased BUN and creatinine levels; normal to increased alanine aminotransferase secondary to hypoxia-related hepatocellular damage. Rarely, hypoglycemia may be noted as with primary absolute polycythemia.

- Inappropriate secondary absolute polycythemia: Same as primary absolute polycythemia.

Urinalysis

- In relative polycythemia, if renal function is normal, urine specific gravity is increased to above 1.030 for dogs and above 1.035 for cats.

- In the remaining categories, urine specific gravity ranges from concentrated to minimally concentrated; this may be variable depending on the severity of the patient’s polyuria and polydipsia.

- In inappropriate secondary absolute polycythemia, hematuria may be associated with neoplasia (e.g., renal carcinoma).

Other Diagnostic Findings

Thoracic Radiographs

For all types of polycythemia, there may be no significant radiographic findings.

- Relative polycythemia: Microcardia, small pulmonary vessels, small caudal vena cava.

- Primary absolute polycythemia: Prominent vasculature (i.e., enlarged pulmonary arteries with pulmonary hypertension).

- Appropriate secondary absolute polycythemia: Prominent vasculature (i.e., enlarged pulmonary arteries with pulmonary hypertension).

- Inappropriate secondary absolute polycythemia: Prominent vasculature and possible evidence of metastatic disease.

Abdominal Radiographs

- Relative polycythemia: No significant abnormalities, although abdominal radiographs may aid in identifying the underlying cause of dehydration.

- For both primary absolute polycythemia and appropriate secondary absolute polycythemia, no significant abnormalities are identified on abdominal radiographs.

- Inappropriate secondary absolute polycythemia: Evidence of renal or other neoplasia.
Echocardiography
- **Relative polycythemia**: Small chambers consistent with hypovolemia.
- **Primary absolute polycythemia** and **inappropriate secondary absolute polycythemia**: No obvious abnormalities; however, ventricular hypertrophy may be noted.
- **Appropriate secondary absolute polycythemia**: Possible pulmonary hypertension characterized by a high tricuspid regurgitation velocity or high-velocity pulmonic valve insufficiency without evidence of pulmonic stenosis. Evidence of cardiac malformations include tetralogy of Fallot, reverse posterior descending artery (rPDA), atrial septal defect (ASD), and aorticopulmonary window. A bubble study may reveal right-to-left shunting of blood.

Abdominal Ultrasonography
- **Relative polycythemia**: May reveal an underlying disease process resulting in dehydration. Fluid may be present in the abdomen.
- **Primary absolute polycythemia**: No obvious abnormalities. Occasionally, slight splenomegaly is seen.
- **Appropriate secondary absolute polycythemia**: High resistive index may indicate reduced blood flow to the kidneys causing inadequate oxygen delivery and hypoxic damage to the kidneys.
- **Inappropriate secondary absolute polycythemia**: Most commonly, a structural abnormality of the kidney is present. Examination of the kidneys may reveal evidence of neoplasia, cysts, hydronephrosis, or pyelonephritis. Evidence of other neoplasms (e.g., leiomyosarcoma, lymphosarcoma, or fibrosarcoma) may also be seen.

Arterial Blood Gas
- **Appropriate secondary absolute polycythemia**: Low partial pressure of oxygen (PaO₂); arterial oxygen saturation is decreased. Normal, high, or low arterial carbon dioxide tension (PaCO₂). Very rarely, hypoxia may be localized to the kidneys secondary to decreased perfusion, in which case, blood gases are normal.
- In **all other categories**, no abnormalities are noted in PaO₂ or carbon dioxide concentration (PCO₂).

**Erythropoietin Level**
Erythropoietin levels often help to distinguish the cause of polycythemia; however, the erythropoietin level should only be used in combination with other information gathered from the patient. Table 1 provides an explanation of the expected erythropoietin concentration with each form of polycythemia.

**Summary of Diagnostic Criteria**
Common findings among all categories include increased Hct, hemoglobin, and RBC count.

**Relative Polycythemia**
- Other diagnostic findings are in support of the underlying cause of the dehydration.
- Normal erythropoietin concentration.

**Primary Absolute Polycythemia**
- Low to normal erythropoietin concentration.

**Appropriate Secondary Absolute Polycythemia**
- Clinical and arterial blood gas evidence of hypoxemia.
- Abnormal echocardiogram demonstrating evidence of pulmonary hypertension or a right-to-left shunt with or without other malformations.
- Rarely, abdominal ultrasonography may show evidence of decreased perfusion to the kidneys.
- Normal to high erythropoietin concentration.

**Inappropriate Secondary Absolute Polycythemia**
- Evidence of renal neoplasia or other abnormality on abdominal ultrasonography.
- Evidence of other neoplasia.
- Normal to high erythropoietin concentration.

**Diagnostic Differentials**
Figure 2 provides an overview of the diagnostic algorithm for polycythemia.

**Relative Polycythemia**
History combined with physical examination may identify the underlying cause of dehydration. The dif-
Diagnostic algorithm for polycythemia. ASD = atrial septal defect; BUN = blood urea nitrogen; CT = computed tomography; PaO$_2$ = partial pressure of oxygen; PP = plasma protein; RBC = red blood cell; rPDA = reverse patent ductus arteriosus; SG = specific gravity; 2,3-DPG = 2,3-diphosphoglycerate; ToF = tetralogy of Fallot; VSD = ventricular septal defect. (Adapted from Ettinger SJ, Feldman EC: Textbook of Veterinary Medicine, ed 6. Philadelphia, Saunders, 2004, p 218.)
ferential diagnosis is extensive and beyond the scope of this article.

Primary Absolute Polycythemia
• Monoclonal myeloproliferative disorder.
• Congenital erythropoietin receptor abnormality (unrecognized in animals).

Appropriate Secondary Absolute Polycythemia
• Cardiac congenital abnormalities, including tetralogy of Fallot, rPDA, VSD, ASD, and aorticopulmonary window.
• Severe chronic lung disease, especially with ventilation-perfusion mismatch.
• Methemoglobin reductase deficiency may cause slight polycythemia because of increased methemoglobin, which decreases overall oxygen-carrying capacity.
• High-altitude environment. These animals are asymptomatic and do not require treatment.
• Rare causes include massive obesity, neurologic disease with a depressed respiratory center, and renal hypoperfusion.

Inappropriate Secondary Absolute Polycythemia
• Neoplasia: Renal carcinoma, lymphoma, fibrosarcoma, basal fibrosarcoma, cecal leiomyosarcoma.
• Nonneoplastic renal disease: Renal cysts, pyelonephritis (bacterial, Cryptococcus neoformans infection), hydronephrosis.

TREATMENT RECOMMENDATIONS

Initial Treatment
Relative Polycythemia
• Volume expansion with IV crystalloids to correct dehydration and provide maintenance fluid requirements.
• Treatment of the underlying cause of dehydration.

Primary Absolute Polycythemia
• Phlebotomy: Remove 15 to 20 ml/kg of blood by venipuncture to cause a 15% reduction in Hct. This should be followed by replacement of the same amount of volume removed with 0.9% sodium chloride, plasma, or other plasma expanders (e.g., hetastarch). The goal is to decrease Hct to less than 55% in dogs and less than 50% in cats. Adverse effects include thromboembolic events, hypovolemia, and iron deficiency (especially with repeated phlebotomy). If the Hct can be maintained by phlebotomy every few weeks, it may be the only treatment required. If more frequent phlebotomy is necessary, chemotherapy is indicated.
• Hydroxyurea: Inhibitor of DNA synthesis.
  — Dogs: 30 mg/kg PO for 7 to 10 days and then decreased to daily oral maintenance therapy at 15 mg/kg. This can be later titrated to the lowest dose that will maintain a near-normal Hct.
  — Cats (suggested dose): 125 mg PO every 2 days for 2 weeks and then 250 mg twice weekly for 2 weeks. After Hct is stable, the dose may be lowered to the lowest effective dose. Higher doses should be given only if absolutely needed (and under supervision in the hospital) because of the risk of methemoglobinemia in cats (see below).
  — Adverse effects include gastrointestinal effects (anorexia, vomiting, diarrhea), bone marrow suppression (anemia, thrombocytopenia, leukopenia), and pulmonary fibrosis. Other reported side effects include stomatitis, sloughing of the nails, alopecia, and dysuria. Methemoglobinemia is a significant and life-threatening side effect in cats. Adverse effects can usually be reversed with discontinuation of the drug. The drug can then be restarted at a lower dose.

Appropriate Secondary Absolute Polycythemia
• Phlebotomy as directed above. These patients may do better if Hct is allowed to remain around 55% to 60% because they need the additional oxygen-carrying effect, but hyperviscosity is detrimental. Caution needs to be exercised in patients with cardiac or pulmonary abnormalities because these animals are already volume expanded and have a higher likelihood of developing complications of volume overload (e.g., congestive heart failure). These patients may do better without replacing the blood volume removed with fluids.
• Hydroxyurea as dosed above has also been used for long-term management of dogs with congenital cardiac abnormalities to avoid phlebotomy. Hct is reduced to a level where hyperviscosity is tolerable without causing complications while maintaining the oxygen-carrying capacity at a level at which patients do not have clinical signs.
• Weight reduction if the patient is obese.

Inappropriate Secondary Absolute Polycythemia
• Phlebotomy as directed for primary polycythemia.
• Surgical resection of erythropoietin-secreting tumors or masses followed by chemotherapy or radiation therapy, if indicated.
• Medical management of the underlying renal disease, if possible (i.e., antibiotics for bacterial pyelonephritis, aspiration of cystic fluid from renal cysts). If this fails, surgical nephrectomy for renal cysts can also be pursued.
Alternative/Optional Treatments/Therapy

- In human medicine, **leeching** is an alternative to phlebotomy in patients when venipuncture is unsuccessful.
  - Each leech is able to suck approximately 10 ml of blood, and after the leech has fallen off, an additional 10 ml of blood oozes from the site of suction.
  - Adverse effects that may be seen when using leeches for phlebotomy include allergic reactions, anemia, transmission of infectious agents (including *Trypanosoma cruzi*), scar formation, and aberrant leech migration before attachment to the suction site.

- **Radioactive phosphorus** has been used for the treatment of primary erythrocytosis; however, it is not routinely available and carries additional concerns about exposure of the pet owner and family members to radioactivity. It incorporates into the calcium phosphate of bone tissue.
  - Myelosuppression is accomplished via irradiation of adjacent bone marrow cells that are undergoing proliferation.
  - Success of this procedure has been inconsistent, and because other therapies are available, it is not commonly used.
  - The dose is not established, but the range has been reported as 2.1 to 3.0 µCi/m².
  - In human patients, myelofibrosis and myelogenous neoplasia have been long-term complications.

Supportive Treatment

- **Aspirin**: 0.5–1.0 mg/kg/day for dogs and 80 mg twice weekly for cats to help prevent thrombosis.

- **Iron supplementation**: 50 mg of iron is lost with removal of each 100 ml of blood. This deficit can be replaced via IM injection of 100 to 300 mg/day of iron dextran or ferrous sulfate PO (lower doses are given for cats and small dogs).

Patient Monitoring

Relative Polycythemia

- Monitoring should target the underlying cause of the dehydration.
- Hct should be rechecked within 12 hours while the patient is in the hospital. An elevated Hct level should decrease with appropriate therapy.

Primary Absolute Polycythemia

- After phlebotomy, Hct should be checked every 1 to 2 weeks at first and then less frequently as Hct stabilizes.
- If using hydroxyurea or radiophosphorus, the complete blood count should be monitored weekly to check for bone marrow suppression; after the patient is stable, monitoring should be done on a monthly basis.
- At home, the owner should monitor for recurrent clinical signs indicating the need for additional phlebotomy (i.e., hyperemia of mucous membranes, neurologic signs, lethargy, or polyuria and

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**ON THE NEWS FRONT**

- Endogenous erythroid colony assay has been used in human medicine to differentiate between primary and secondary polycythemia. It assesses erythropoietin-independent proliferation of erythroid progenitors and can be performed using either bone marrow or peripheral blood samples. Proliferation of erythroid progenitors without the addition of serum or cytokines provides a diagnosis of primary absolute polycythemia.

- Interferon-α has been used in the long-term management of polycythemia vera in humans as an alternative to hydroxyurea. The mechanism of action is via direct inhibition of hematologic progenitors and cytokine-mediated effects. It inhibits erythroid progenitors, including burst-forming units-erythroid in vitro. In humans, treatment with interferon has decreased the incidence of myelofibrosis. Interferon has been used in dogs and cats for the treatment of retroviral, ocular, and neoplastic diseases, and administration via injection is preferred because oral absorption is minimal.

- Excessive blood transfusion and erythropoietin have also been reported as iatrogenic causes of polycythemia. Administration of recombinant human erythropoietin (rHuEPO) may be used to enhance performance in racing greyhounds and equine athletes. Recently, urine testing using the World Anti-Doping Agency–approved isoelectric focusing immunoblotting confirmatory technique was performed to detect rHuEPO in the urine of greyhounds.

- Prophylactic antibiotics should be used to prevent infection when using leeches to perform phlebotomy.

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**Excessive Blood Transfusion and Erythropoietin**

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- **Iron Supplementation**: 50 mg of iron is lost with removal of each 100 ml of blood. This deficit can be replaced via IM injection of 100 to 300 mg/day of iron dextran or ferrous sulfate PO (lower doses are given for cats and small dogs).

- In cases of chronic pulmonary disease, treating the underlying cause and improving oxygenation aid in the management of recurring polycythemia.

**Patient Monitoring**

**Relative Polycythemia**

- Monitoring should target the underlying cause of the dehydration.
  - Hct should be rechecked within 12 hours while the patient is in the hospital. An elevated Hct level should decrease with appropriate therapy.

**Primary Absolute Polycythemia**

- After phlebotomy, Hct should be checked every 1 to 2 weeks at first and then less frequently as Hct stabilizes.
- If using hydroxyurea or radiophosphorus, the complete blood count should be monitored weekly to check for bone marrow suppression; after the patient is stable, monitoring should be done on a monthly basis.
- At home, the owner should monitor for recurrent clinical signs indicating the need for additional phlebotomy (i.e., hyperemia of mucous membranes, neurologic signs, lethargy, or polyuria and
polydipsia). This depends on the clinical signs with which the patient initially presented.

**Appropriate Secondary Absolute Polycythemia**
- Monitoring should be done for changes in respiratory rate; the presence of dyspnea or cyanosis; and changes in attitude, especially signs consistent with polycythemia that indicate phlebotomy is again necessary.
- If using drug therapy, monitoring should be done as recommended above.
- Hct should be monitored to assess the degree of elevation.

**Inappropriate Secondary Absolute Polycythemia**
- If secondary to neoplasia, monitoring may be dictated by postsurgical oncology recommendations.
- If caused by renal disease, urinalysis, culture, and chemistry should be monitored to assess the recurrence or progression of the renal disease.

**Home Management**

**Relative Polycythemia**
- Depends on the underlying cause.

**Primary Absolute Polycythemia**
- Recurrent clinical signs or new clinical signs related to polycythemia should be monitored.

**Appropriate Secondary Absolute Polycythemia**
- To prevent an increase in oxygen requirements, exercise should be restricted and stress should be reduced.
- Weight should be monitored to maintain a body condition score of 4/5 of 9.

**Inappropriate Secondary Absolute Polycythemia**
- Recurrent clinical signs or new clinical signs related to polycythemia should be checked.
- Evidence of renal disease, including polyuria and polydipsia, decreased appetite, and lethargy, should be monitored.

**Milestones/Recovery Time Frames**
- Patients should show marked improvement or resolution of clinical signs within 24 hours after phlebotomy.
- The interval between phlebotomies can vary widely among patients, with some requiring just one phlebotomy and others needing phlebotomies every 1 to 2 weeks. If the underlying cause is corrected, further polycythemia should not occur. If primary absolute polycythemia is diagnosed, monitoring for trends and establishing a predictable interval between phlebotomies is beneficial. This interval may help with the decision to use drug therapy to control polycythemia and the dose needed for maintenance.

**Treatment Contraindications**
- Phlebotomy is contraindicated in hypovolemic patients.
- Hydroxyurea should not be used in patients with evidence of bone marrow suppression or in patients demonstrating gastrointestinal signs. Hydroxyurea should be used with caution in patients with infections or renal insufficiency, in patients that have received previous chemotherapy or radiotherapy, and in all cats.
- Radiophosphorus should not be used in patients with evidence of bone marrow suppression.

**PROGNOSIS**

**Favorable Criteria**

**Relative Polycythemia**
- Rapid improvement with fluid replacement and treatment of the underlying disorder.

**Primary Absolute Polycythemia**
- Resolution of clinical signs after phlebotomy.
- Prolonged interval between phlebotomies.
- Good response to chemotherapy.

**Appropriate Secondary Absolute Polycythemia**
- Improvement in clinical signs after phlebotomy.
- Prolonged interval between phlebotomies.
- Improvement in heart or lung disease after medical management.
- If secondary to obesity, improvement or resolution after significant weight loss.

**Inappropriate Secondary Absolute Polycythemia**
- No evidence of metastasis.
- Complete resolution of clinical signs with medical or surgical management of the underlying cause.

**Unfavorable Criteria**

**Relative Polycythemia**
- Persistent clinical signs despite fluid replacement.

**Primary Absolute Polycythemia**
- Short interval between phlebotomies despite the addition of drug therapy.
- Need for multiple phlebotomies to avoid development of clinical signs.

**Appropriate Secondary Absolute Polycythemia**
- PaO₂ <60 mm Hg or severe underlying cardiac disease.
- Evidence of compensatory heart changes in relation to heart defects.
- Short interval between the need for phlebotomies despite the addition of drug therapy.

**STANDARDS of CARE: EMERGENCY AND CRITICAL CARE MEDICINE**
- Lack of improvement after medical management for heart or chronic lung disease.

**Inappropriate Secondary Absolute Polycythemia**
- Metastatic neoplasia.
- Renal failure.
- Resistant or untreatable infection causing renal hypoxia (rare).

**RECOMMENDED READING**


