CHAPTER 1

An introduction to SIRS and the Rule of 20

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Introduction to the Rule of 20 and inflammatory response syndromes

Heat stroke, peritonitis, parvovirus diarrhea, systemic lymphosarcoma, leptospirosis, massive trauma, gastric dilation-torsion, aspiration pneumonia, pancreatitis, immune-mediated disease, and postoperative laparotomy are but a sampling of the multitude of potentially life-threatening disorders that can affect the small animal intensive care unit (ICU) patient. These and other disorders share a common pathophysiology: an inciting stimulus initiates the production and release of circulating mediators that cause systemic inflammatory changes.

Inflammation can be defined as a localized protective response elicited by injury or destruction of tissues that serves to destroy, dilute, or wall off both the injurious agent and the injured tissue [1]. Chemical mediators are released in response to an inciting antigen and initiate the innate immune response that causes inflammation. The classic signs of inflammation are heat, redness, swelling, pain, and loss of normal function. These are manifestations of the physiological changes that occur during the inflammatory process: (1) vasodilation (heat and redness), (2) increased capillary permeability (swelling), and (3) leukocytic exudation (pain). The initial inflammatory response to a localized insult is good, serving to localize the problem, destroy an offending pathogen, clean up damaged tissues, and initiate the healing process.

However, many ICU patients develop a negative trajectory when the inflammatory mediators and their response have systemic consequences. When this occurs due to an infection, it is called sepsis, and when it progresses, it often results in multiple organ dysfunction syndrome (MODS) or multiple organ failure (MOF).

It might appear logical that an overwhelming infectious agent could stimulate systemic inflammation. Yet, an almost identical clinical progression has been commonly observed in response to conditions that are not due to infection (such as trauma, surgery, and certain metabolic diseases). The term "sepsis syndrome" was first used to describe this in human patients when they appeared to be septic but had no obvious source of infection [2–4].

By the mid-1990s, sepsis syndrome had evolved into the nomenclature of systemic inflammatory response syndrome (SIRS). It was discovered that the body can respond to noninfectious insults and tissue injury in the same exaggerated manner that it does to microbial pathogens, with an almost identical pathophysiology [5]. In sepsis, pathogen-associated molecular patterns (PAMPs), expressed by the pathogen, stimulate pattern recognition receptors (PRRs) in the host. With noninfectious diseases, damaged tissues also release endogenous mediators, such as alarmins and damage-associated molecular pattern (DAMP) molecules (such as heat shock proteins, HMGB-1, ATP, and DNA). These will stimulate the toll-like receptor, PRRs or other receptor systems that typically respond to microbes and activate immune cell responses [6–8]. A list of proinflammatory cytokines associated with SIRS is provided in Table 1.1. Figure 1.1 provides a schematic of many of the proinflammatory changes that occur in this syndrome.

Soon the one-hit and two-hit models of MODS caused by SIRS were recognized in humans; one hit results from an initial massive insult (traumatic, metabolic, infectious), culminating in early SIRS and MODS. The two hits occur when a severely injured patient is successfully resuscitated, followed by a second inflammatory insult which amplifies SIRS and results in MODS [9,10]. It was discovered that an antiinflammatory response occurred after the initial inflammatory response as well. This compensatory antiinflammatory response syndrome (CARS) is characterized by increased appearance of antiinflammatory cytokines and cytokine agonists found in the circulation [11]. These antiinflammatory mediators were found for days or weeks after the proinflammatory mediators had gone [12]. Macrophage dysfunction is a significant contributor to CARS, with a decreased capacity to present antigens and release proinflammatory cytokines [13]. It was found that the T-cells are defective and depleted due to apoptosis and decreased proliferation [14]. In addition, there is an increase in the suppressor cell populations [15]. Many of the cytokines released during CARS are listed in Table 1.1. Figure 1.2 provides a schematic of many of the antiinflammatory changes that occur during this process.

It was determined that the production of proinflammatory and antiinflammatory cytokines occurs simultaneously, with antiinflammatory gene expression paralleling the increased expression of proinflammatory genes [16]. It was then proposed that the induction of SIRS and CARS occurs simultaneously [17]. The emergence of myeloid-derived suppressor cells (MDSCs) results in suppression of T-cell responses through increased production of nitric oxide and reactive oxygen species. The increase in MDSCs is proportional to the severity of the inflammatory insult [17].

Although the pathophysiology has not been clearly defined for the SIRS-CARS phenomenon, the basic hemodynamic consequences have been identified. Once the mediators have entered the circulation, the progression and complications are similar for each inciting disease: peripheral vascular dilation, increased capillary permeability, and depressed cardiac function. Three forms of shock are known to occur simultaneously in these patients: hypovolemic, distributive, and cardiogenic (see Figure 1.3). Once shock ensues, MODS is likely to occur if aggressive patient support has been delayed.

Monitoring and Intervention for the Critically Ill Small Animal: The Rule of 20, First Edition. Edited by Rebecca Kirby and Andrew Linklater.

Table 1.1 Inflammatory and hemostatic mediators of severe sepsis and their effects. Adapted from: Balk RA, Ely EW, Goyette RE. Stages of infection in patients with severe sepsis. In: Sepsis Handbook, 2nd edn. Thomson Advanced Therapeutics Communication, 2004, pp 24–31.

Proinflammatory mediators

Tumor necrosis factor
- IL-6 induction, TF expression, downregulation of TM gene expression and increased catabolism, activation of fibrinolysis, cytotoxicity, upregulation of endothelial cell adhesion molecules, induction of NO synthase, neutrophil activation, antiviral activity, fever, and other effects; circulating soluble receptor is antagonist

Interleukin-1
- Fever, synthesis of acute-phase proteins, induction of IL-6 synthesis, upregulation of TF expression, decreased TM expression, activation of fibrinolysis, and other effects

Interleukin-6
- Induction of acute-phase response, induces B-cell growth and T-cell differentiation, enhances NK-cell activity, promotes maturation of megakaryocytes, can inhibit endotoxin-induced IL-1 and TNF-alpha; circulating soluble receptor is agonist

Interleukin-8
- Release stimulated by TNF, IL-1, IL-2, promotes chemotaxis, enhances neutrophil function, upregulates adhesion molecule expression, level correlates with severity of systemic manifestation of pathology

Interferon-gamma
- Induction of IgG production, potentiation of activity of IL-12, macrophage activation

Antiinflammatory mediators

Interleukin-4
- Stimulation and inhibition of various classes of T-cells, suppression of TNF and IL-1 secretion, upregulation of IgE and IgG secretion

Interleukin-10
- Inhibition of inflammatory cytokine production by mononuclear cells, suppression of monocyte procoagulant activity, downregulation of monocyte killing, share receptor homology with interferon

Transforming growth factor-beta
- Tissue development and repair, other antiinflammatory properties

Soluble receptor and receptor antagonists
- Soluble TNF-1 receptor and IL-1 soluble receptor inhibit function

Hemostatic factors

Tissue factor
- Upregulates expression on monocytes and subset of endothelial cells by TNF and IL-1 leading to stimulation of extrinsic coagulation cascade

Thrombin
Protein C
Protein S
Antithrombin
Plasminogen activator inhibitor-1
Tissue factor pathway inhibitor
Plasmin
Thrombin activatable fibrinolysis inhibitor

Other mediators

Nitric oxide
Bradykinin
Lipopolysaccharide binding protein
Complement
Leukotrienes
Prostaglandins
Superoxide radicals
Platelet activating factor
Myocardial depressant factor

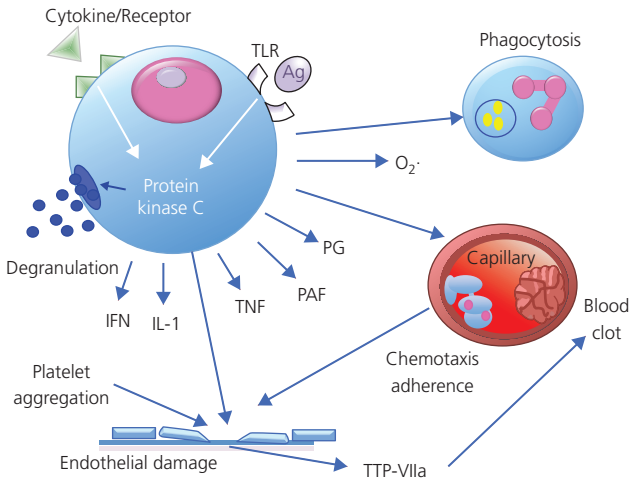

Figure 1.1 A schematic of some of the major consequences of the proinflammatory component of systemic inflammatory response syndrome (SIRS). Many cells produce proinflammatory mediators, including monocytes, macrophages, and endothelial cells. The interaction of an antigen (microbial or tissue based) with its receptor will cause the stimulation of protein kinase C and the production of cytokines. Cytokines in the circulation will interact with their specific receptor on other cells and stimulate the production of more cytokines. In addition to the release of cytokines (IFN, IL-1, TNF), the arachidonic acid cascade is stimulated and produces PG, PAF, and leukotrienes. Reactive oxygen species are produced as well. Some of the consequences include degranulation of white cells, endothelial damage, stimulation of coagulation, white blood cell chemotaxis and adherence in capillaries, and increased phagocytosis of Ags. Ag, antigen; IFN, interferon; IL, interleukin; O_2^-, superoxide radicals; PAF, platelet activating factor; PG, prostaglandins; TNF, tumor necrosis factor; TLR, toll-like receptor; TTP, tissue thromboplastin; VIIa, activated factor VII.

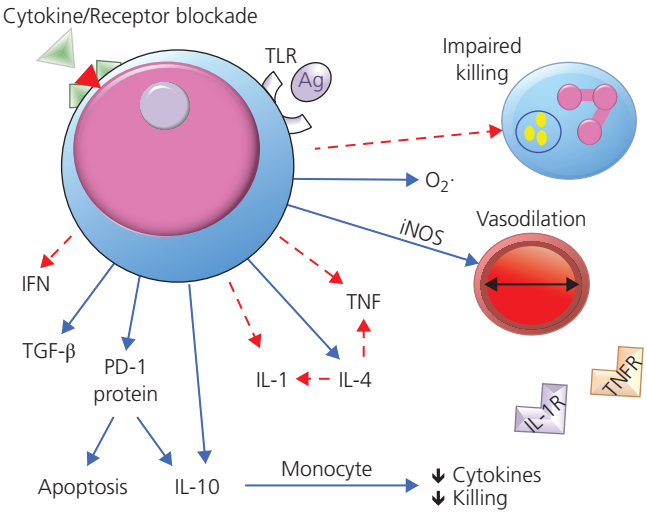

Figure 1.2 A schematic of some of the major consequences of the antiinflammatory component of the compensatory antiinflammatory response syndrome (CARS). Red dotted lines depict inhibitory actions, blue solid lines depict stimulatory action. T-cells, monocytes, and macrophages are the primary cells affected. The same antigens (microbial or tissue based) that stimulate the proinflammatory response can also stimulate the antiinflammatory cascades. The antiinflammatory mediators will block the production of many of the proinflammatory cytokines (*red triangle and red dotted lines*). TNF and IL-1 receptors are found in the circulation and will bind and inactivate TNF and IL-1 proinflammatory mediators. Ag, antigen; IFN, interferon; IL, interleukin; IL-1R, interleukin-1 receptor; iNOS, inducible nitric oxide synthetase; O_2^-, superoxide radicals; PD-1, programmed death-1; TGF-β, tissue growth factor-beta; TLR, toll-like receptor; TNF, tumor necrosis factor; TNFR, tumor necrosis factor receptor.

Many research and clinical trials have been conducted in laboratory animals and humans looking for a single best therapy that would be effective in treating most patients with the SIRS-CARS phenomenon, with minimal success. Since inflammation and immune suppression have been found to be occurring simultaneously, each patient is more likely to be experiencing their own unique combination of immune stimulation and suppression. This makes a standardized protocol for therapy extremely difficult to formulate until further knowledge is acquired. Emphasis is no longer primarily directed at methods to stop exaggerated proinflammatory responses but is instead placed on supporting the patient and searching for new methods that prevent prolonged immunosuppression or restore immune function [18].

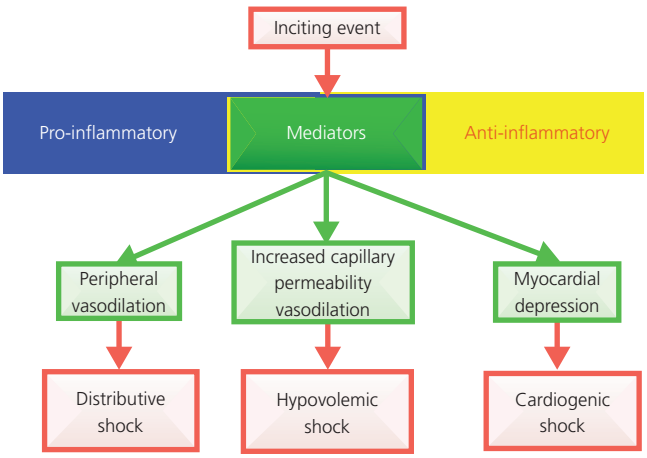

Figure 1.3 A schematic depicting the presence of proinflammatory (*blue*) and antiinflammatory (*yellow*) mediators released concurrently (*green*), causing hemodynamic changes that result in three simultaneous forms of shock.

Sepsis, the SIRS-CARS phenomenon (referred to simply as SIRS from here on), and MODS remain tremendous obstacles to the successful treatment of critically ill small animals. A "back to basics" approach is critical for any patient with the potential for inflammatory changes. Several basic yet key principles that can be used to guide patient assessment and care are listed in Box 1.1. Problems within the major organ systems should be anticipated in advance, with appropriate diagnostic, therapeutic, and monitoring efforts employed early, rather than waiting for a problem to surface and reacting to it. The Rule of 20 was developed to assist the critical care team in thoughtfully and carefully assessing these patients. Table 1.2 lists common problems to anticipate under each parameter of the Rule of 20 in patients with SIRS. Sample forms that can be used when applying the Rule of 20 are provided in Figures 1.4 and 1.5.

The critical care team must remain open to options for the diagnosis and care of the patient when changes in patient status occur and must reconsider differentials when a patient is not progressing

Box 1.1 Key principles to guide the care of the small animal ICU patient.

- Treat the most life-threatening problem first
- Treat the patient, not the numbers
- Anticipate the worst and be ready for it
- Provide the right treatment, at the right time, in the right amount
- Examine the cause of the problem and the effect on the patient
- Weigh the pros and cons of every drug and procedure
- There is not a drug for every problem – less is best
- If it has not been written down, it has not been done
- Never ignore your gut feeling
- Things are done in the order of importance

Table 1.2 Common problems to anticipate for each parameter of the Rule of 20 in the SIRS patient.

Rule of 20 parameter	Anticipated problems
Fluid balance	Hypovolemia; vasodilation, increased capillary permeability
Albumin, COP	Hypoalbuminemia; loss through capillaries and catabolic state; reduced COP and extravasation of fluid from vasculature
Blood pressure	Hypotension; hypovolemia and impaired cardiac performance, peripheral vasodilation
Glucose	Hypoglycemia; increased consumption, decreased intake; can affect vascular tone and cardiac performance
Electrolytes	Hypokalemia; any disorder is possible with fluid imbalances, catabolic state, and depressed nutritional intake
Acid–base	Metabolic acidosis associated with poor perfusion and elevated lactate is common
Oxygenation/ventilation	Hypoxemia possible if pulmonary edema from inflammatory vascular changes or poor cardiac performance
Coagulation	Thrombocytopenia (declining trend); some form of DIC due to mediator-induced vasculitis, activation of serine proteases, and insufficient antithrombin
Red blood cells	Anemia from disease or erythrocytosis from dehydration; frequent blood sampling can result in anemia
Heart rate, rhythm, contractility	Tachycardia in dogs with poor perfusion, bradycardia in cats with poor perfusion; arrhythmias if poor perfusion; depressed myocardial contractility with circulating mediators
Neurological status	Depressed level of consciousness from perfusion changes, hypoxemia if present, circulating mediators, metabolic changes or underlying disease
Urinary tract status	Azotemia if poor perfusion or dehydration; impaired renal function if prolonged hypotension or nephrotoxic drugs
WBC, immune status	Impaired immune function, lymphopenia possible, susceptible to nosocomial infections
Gastrointestinal status	Gastric paresis, ileus; third body fluid spacing into bowel; bacterial translocation if no enteral feeding
Nutrition	Catabolic state and early malnutrition anticipated; bacterial translocation without enteral feeding
Drugs	Altered volume of distribution, metabolism and excretion
Body temperature	High if active inflammation; low in cats with poor perfusion or dogs with difficult-to-resuscitate shock
Pain control	Pain is anticipated with all critical illness and deserves analgesic support; critical early in shock resuscitation
Wound and bandage care	Possible source of pathogens requiring close monitoring of wound sites and bandage changes
Nursing care and TLC	Must receive the right treatment at the right time in the right amount; anticipate problems, be ready; provide TLC

COP, colloidal osmotic pressure; DIC, disseminated intravascular coagulation; TLC, tender loving care; WBC, white blood cell.

as expected. A problems list for the patient should be established and revised at least daily, with options for diagnostic, therapeutic, and monitoring plans for each problem outlined and considered (Figure 1.6). A differential diagnosis list is prepared for each problem and frequently reevaluated with the goal of finding one diagnosis that could be responsible for all the listed problems.

There are many aspects of critical care that are unique to the cat. Challenges occur when treating the cat due to species differences such as their physiological response to shock, the specific methods required for shock resuscitation and the different drug responses, metabolism, and dosing requirements. Knowledge of the traits specific to the cat is mandatory for optimizing their ability to recover from critical illness. These differences are highlighted in each chapter throughout the Rule of 20.

The successful treatment of SIRS and MODS has lead to the emergence of a new syndrome identified in human medicine, the persistent inflammation/immunosuppression catabolism syndrome (PICS) [17]. Secondary nosocomial infections and severe protein catabolism are hallmarks of PICS. This syndrome presents the simultaneous challenge of managing chronic inflammation and immunosuppression. These patients are identified in the surgical ICU after ≥10 days and have persistent inflammation defined by findings such as elevated C-reactive protein, lymphopenia (<800/mm^3), serum albumin < 3 g/dL, and weight loss >10%.

A study of adult humans suffering severe blunt trauma found that patients with complicated clinical outcomes are exhibiting PICS [19]. These patients were reported as being significantly older and sicker, with persistent leukocytosis but low lymphocyte and albumin levels compared with uncomplicated patients. They expressed significant suppression of myeloid cell differentiation, increased inflammation, decreased chemotaxis, and defective innate immunity compared with uncomplicated patients. Genomic analysis found changes consistent with defects in the adaptive

Rule of 20 Parameters	
☐ Fluid balance	☐ Neurological status
☐ Blood pressure	☐ Urinary tract status
☐ Albumin, COP	☐ WBC, Immune status
☐ Glucose	☐ GI tract status
☐ Electrolytes	☐ Nutritional status
☐ Acid – base	☐ Drug dosing, metabolism
☐ Oxygenation/ventilation	☐ Body temperature
☐ Coagulation	☐ Pain control
☐ Red blood cell status	☐ Wound and bandage care
☐ Heart rate, rhythm, contractility	☐ Nursing care, TLC

Figure 1.4 The Rule of 20. Each parameter should be assessed regularly in any critically ill dog or cat. The order of importance will vary between individual patients. COP, colloidal osmotic pressure; GI, gastrointestinal, TLC, tender loving care; WBC, white blood cell.

Problems list	Dx plan	Rx plan	Mx plan
Poor perfusion Tachycardia, Pale MM, CRT 3 sec	Doppler BP CVP when stable	Crystalloids, HES high normal end-points; large volume technique	Doppler BP CVP, UO physical perfusion parameters
Vomiting Yellow liquid	POC database, CBC, UA, biochemistry, radiographs when stable	Fluid therapy NPO anti-emetics ± NG tube	PE for hydration and perfusion frequency of vomiting

Figure 1.6 An example of a worksheet to ensure that each patient problem has a diagnostic, therapeutic, and monitoring plan. The worksheet has some examples of problems to demonstrate the intention of the form. Each of the problems that the patient has that day should be listed in the left-hand column. New and unresponsive problems deserve a diagnostic, therapeutic, and monitoring plan written down. After assessing each problem and possible plan, the task of choosing the most efficient means for patient diagnosis and care can be performed. Dx, diagnostic; Mx, monitoring; Rx, therapeutic.

Parameter	Patient	Target	Intervention	Parameter	Patient	Target	Intervention
Fluid balance				Heart rate, rhythm, contractility			
Blood pressure				Neurological status			
Oncotic pull /albumin				Urinary tract status			
Glucose				WBC, immune status, antibiotics			
Electrolytes				Gastrointestinal status			
Acid–base				Nutritional status			
Oxygenation & ventilation				Drugs, dosage, metabolism			
Coagulation				Pain			
RBCs				Wounds, bandages			
Temperature				Nursing care			

Figure 1.5 Rule of 20 form for recording current patient status, targeted endpoints, and proposed intervention. RBC, red blood cell; WBC, white blood cell.

immune response and increased inflammation. Clinical data showed persistent inflammation, immunosuppression, and protein depletion.

Unfortunately, at this time, when PICS is recognized, the course correction is difficult. Therapeutic interventions are geared towards supportive care and treating secondary infections. Further research is needed to identify appropriate multimodal therapies that target specific components of the syndrome [16]. The Rule of 20 now becomes even more important for thoroughly assessing and supporting these critical patients.

Diagnostic and monitoring procedures

The practice of medicine is an art that depends on the ability to successfully acquire and integrate the findings from the patient history, physical examination (PE), and cage-side point of care (POC) laboratory database. Patients continuously give important information through their physical changes, progression of illness, and clinical signs. Additional diagnostic testing is done to confirm, deny or better define the clinical impressions gained from evaluation of the patient status and underlying disease(s). It is not uncommon for life-threatening problems to require stabilization before time-consuming or invasive diagnostic and monitoring procedures are employed.

The history and physical examination

The key to taking a great history is organization. A sample format for obtaining a sequential history pertaining to the small animal ICU patient is presented in Table 1.3. The order in which the topics are addressed is specifically arranged to better direct information gathering while allowing the owner to describe their concerns about their pet.

Frequently reported complaints elicited from the history (such as vomiting, inability to walk, diarrhea) require further characterization to localize the disease or indicate the severity of the problem. Discussions about significant historical data pertaining to each of the Rule of 20 topics can be found in the corresponding topic chapter.

Each member of the critical care team will develop his or her own style and routine for performing a PE for individual patients. The key is to be consistent and thorough. A rapid evaluation of the ABCs (Airways, Breathing, Bleeding, Circulation, Consciousness) is the first priority, with intervention provided when potentially life-threatening problems are identified. Developing a head-to-tail system of examination helps to maintain a routine and remain focused. Saving the examination of the body parts most likely related to the presenting complaint to the end of the PE can help prevent distraction and failure to complete the remainder of the PE. It is best to perform the equipment-dependent examinations at the end of the PE to avoid distraction.

As the PE progresses from head to tail, neurological and orthopedic evaluations are done along with the general PE. Any animal that has had head trauma, loss of consciousness, prolonged seizures, or other indication of intracranial edema or hemorrhage must maintain a normal head position throughout the examination. When an area of pain is identified, examination of that area is postponed and the general PE is continued, followed by a closer assessment of the painful region. Significant PE findings relative to each of the Rule of 20 topics are discussed in the corresponding topic chapter.

Table 1.3 Example of a format for obtaining a sequential history relevant to the small animal ICU patient. The recommended sequence of questioning is shown and is directed at controlling the conversation while meeting the needs of the client to tell their story about their pet.

Format for history	Notes
Signalment	Alert for age, breed and intact reproductive tract related disorders
Presenting complaint	Noted by staff at time of presentation and recorded. Best not to start history with this inquiry in order to control the historical sequence of the problem
Last normal	Inquire when patient was last absolutely normal, may be abnormal prior to presenting complaint. Differentiates peracute, acute, chronic, and acute-on-chronic problems
Progression	Outline of sequence of changes occurring in the patient from the time of "Last normal" until the present day
Characterization of problems	Identified problems are characterized (such as volume, rate, consistency, color, sound, intensity, duration). Individual problems in the Rule of 20 are discussed in individual chapters
Systems review	Report on problems or systems not discussed related to the current problems and progression. Examples include: vomiting, diarrhea, coughing, sneezing, nasal or ocular discharge, seizures, fainting, weakness, water intake, urination frequency and effort, urine color, stool consistency
Past medical history	Vaccination, heartworm, and parasite control are listed. Any blood transfusions, problems with anesthesia or sedation are reported. Past medical problems and laboratory results of concern
Medications	List prescribed, over the counter and supplements given to the animal. Medications taken by the owner may be important if patient exposure is possible
Exposure to toxins or infectious disease	Inquire about the patient environment including outdoor habits, ill animals or people, groups of animals, new products or people and other lifestyle habits
Nutrition	Inquire about type, quantity, and brand of food, feeding routine, appetite, access to water, weight gain or loss

Point of care testing

The most important and immediate laboratory assessment of the ICU small animal patient is done at the cage side with POC testing. The minimum database should include the packed cell volume (PCV), plasma total protein (TP), blood glucose, blood urea nitrogen (BUN or creatinine), electrolytes, acid–base status, blood lactate, coagulation profile, blood smear for platelet estimate and red blood cell (RBC) morphology, and urinalysis.

There are several POC data points that, when abnormal, warrant immediate investigation and intervention (indicated by red checkmarks in Table 1.4). The significance of the abnormalities with the possible cause(s), intervention options, and monitoring recommendations are available under the corresponding topic chapters.

The microhematocrit tube provides a great deal of data. Figure 1.7 illustrates information that can be obtained from the spun tube, including the PCV, TP, buffy coat, and serum color. The PCV and

Table 1.4 Point of care (POC) blood values of concern.

Factor	Value
✓PCV	>60% or <20%
✓TP	>9.0 or <5.0 g/dL
✓Glucose	<60 mg/dL (3.3 mmol/L)
	>200 mg/dL (11.1 mmol/L)
✓BUN	>40 mg/dL (14 mmol/L)
	<5 mg/dL (1.8 mmol/L)
✓Lactate	>2.0 mmol/L
✓Electrolytes	Na^+ >170 or <135 mEq/L*
	K^+ >6.0 or <3.0 mEq/L*
	$Ca i^{++}$ >6.0 or <3.0 mmol/L
	Cl^- >125 or <110 mEq/L
✓Acid–base	pH >7.5 or <7.2
	pCO_2 >50 or <25 mmHg
✓Urinalysis	Renal tubular cell cast
	White or red cell casts
	Glycosuria with normal blood glucose
	Specific gravity <1.004
	Protein ≥3+

BUN, blood urea nitrogen; PCV, packed cell volume; TP, total protein; i, ionized.
* (mEq/L = mmol/L).

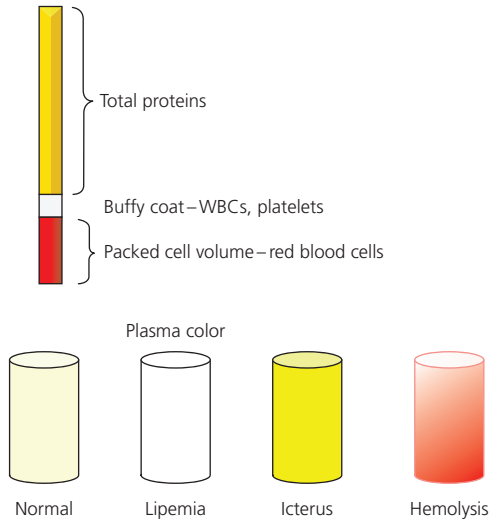

Figure 1.7 Schematic of benefits of the microhematocrit tube in POC testing. After the tube has been centrifuged, the top portion contains the total protein fraction, the small white layer is the buffy coat containing the white blood cells and platelets, and the bottom red portion is the packed cell volume. The lower columns serve as a reminder that the color of the plasma should also be noted: normal (straw colored), lipemia, icterus, or hemolyzed are the most common abnormalities.

TP are evaluated together, with the most common interpretation of changes presented in Table 1.5.

The white layer in the hematocrit tube, between the plasma and the RBCs, consists of the white blood cells (WBCs) and platelets, called the buffy coat. When this is >1–2%, it suggests high WBC counts, and when <1%, low counts. A slide can be made of this layer and the cells examined for morphology, inclusion bodies or parasites. Platelet estimates are best made from a drop of whole heparinized blood rather than the buffy coat. However, if few or no platelets are seen in the buffy coat, further investigation is warranted regarding platelet count. How to perform a platelet estimate is discussed in Chapter 9, Box 9.3. Even when an acceptable platelet count is found at presentation, a repeated estimate should be made after resuscitation. A declining trend in platelet numbers can be one of the first indications of disseminated intravascular coagulation (DIC). This is to be anticipated in dogs and cats with SIRS.

Urine should be collected prior to fluid resuscitation, when possible, especially for patients with likely infectious or metabolic problems. The ability of the kidneys to concentrate urine is reflected by the specific gravity. Glycosuria without hyperglycemia reflects proximal tubular cell damage, a complication of nephrotoxic drugs or renal hypoxia. Urine sediment is evaluated for casts in animals on nephrotoxic drugs or having experienced severe shock. Urine casts present (from acute to chronic) as cellular casts, followed by coarse granular casts, fine granular casts, and finally hyaline casts. Renal tubular and coarse casts may appear before significant elevations in BUN and creatinine.

Clinicopathological laboratory testing

Blood is collected prior to therapy when possible for a complete blood count and serum biochemical profile to be run at a commercial or in-hospital laboratory. It is often beneficial for the clinical pathologist to look at the blood smear for significant changes in the morphology of the blood cells. These additional data will add to the database and provide more information pertaining to the metabolic status of the patient. Evaluation of renal function, hepatic changes, and white blood cell response to illness is important for every critically ill patient.

Often special tests must be ordered to identify a pathogen, confirm a diagnosis or evaluate the success of treatment in the patient. Common clinicopathological laboratory tests that can be used to better define the cause or impact of a parameter of the Rule of 20 are discussed in each of the corresponding topic chapters.

Diagnostic imaging

Diagnostic imaging will almost always begin with survey radiographs of the affected body area. Orthogonal views are always recommended. Chest and abdominal radiographs are examined for evidence of metastatic disease, organ size, shape and position, and fluid accumulation. Contrast studies can assist in outlining structures or demonstrating dynamic changes.

Ultrasound evaluation provides imaging of the organ structure and differentiation between soft tissue and fluid densities. The focused assessment with sonography in trauma (FAST) techniques for rapid assessment of the chest and abdomen are becoming common triage tools and are outlined in the appropriate topic chapters. Doppler blood flow studies can complement the examination when thrombosis or anomalies of the vasculature are suspected.

Echocardiographic evaluation of the performance and size of the heart chambers provides a noninvasive means of assessing cardiac dynamics. Shunts and heart valve disorders can be more closely evaluated using color flow Doppler techniques. The electrocardiogram (ECG) demonstrates cardiac conduction. Information regarding cardiac assessment is presented in Chapter 11.

Endoscopy, laparoscopy, thoracoscopy, and cystoscopy can each provide images and biopsies and facilitate specific procedures of different organs when indicated. Computed tomography (CT) and magnetic resonance imaging (MRI) with and without contrast can provide more detailed imaging of structures that are poorly defined by ultrasound or radiographs.

Table 1.5 Changes in packed cell volume and total protein and their significance.

Variable value	Cause	Interpretation	Plan
Packed cell volume			
>60%*	General concerns:	Hyperviscosity	Oxygen supplementation
	Hypoxia	Pulmonary disease	Treat cause
	Hemoconcentration	Loss of plasma water	Fluids
	Overproduction	Polycythemia vera	± phlebotomy
<20%	General concerns:	Tissue hypoxia	± transfusion
	Blood loss	Hemorrhage	Hemostasis if warranted,
	Lack of production	Bone marrow problem	treat underlying cause
	RBC destruction	Immune mediated	
Total protein			
>9.0 g/dL	General concerns:	Hyperviscosity	Promote blood flow
	Loss of fluids	Hemoconcentration	Fluids
	Overproduction	Inflammation, cancer	Treat cause
<5.0 g/dL	General concerns:	Loss of COP	Give colloids
	Dilution of plasma	Excessive water	Adjust fluids
	Lack of production	GI or liver disease	Treat cause
	Loss of proteins	Vasculitis, glomerular, hemorrhage	Hemostasis
PCV/TP			
↑ ↑	Hemoconcentration	Loss of plasma water	Fluids
↑ ↓ or N	Blood loss	Splenic contraction	Hemostasis
	Hemoconcentration with	SIRS, liver or glomerular disease	Colloids, fluids
	protein loss or poor production		Treat underlying cause
↓ ↓	Blood loss	Acute hemorrhage	Hemostasis, ± transfusion
	Chronic disease	Liver, glomerular	Treat cause, ± transfusion
N ↓	Protein loss	Liver, glomerular, GI	Colloids, treat cause
	Poor production		

COP, colloidal osmotic pressure; GI, gastrointestinal; PCV, packed cell volume; SIRS, systemic inflammatory response syndrome; TP, total protein (plasma).
* PCV between 60% and 70% can be normal for sight hounds, ferrets, and animals at high altitudes.

Recommendations for diagnostic imaging procedures with suggested techniques (such as contrast studies, FAST examination) are presented for each topic of the Rule of 20 in the corresponding topic chapter.

Monitoring procedures

The PE findings will always provide the most important data regarding the status of the patient. Following the trend of change in every monitored parameter affords more accurate information than assessing a single value. Equipment-based monitoring can include indirect and direct blood pressure, ECG, pulse oximetry, end-tidal CO_2, central venous pressure, urine output, body temperature, and body weight and is readily available for the small animal patient. Serial assessment of blood values, such as PCV, TP, acid–base status, coagulation times, electrolytes and lactate, reflects patient progress and can guide therapy. More sophisticated procedures, such as pulmonary artery catheters, $ScvO_2$, and calorimetry, are presented as options in the appropriate chapters, with known advantages and disadvantages highlighted. Each topic in the Rule of 20 will require patient monitoring. The recommended monitoring procedures are discussed in each corresponding topic chapter.

Communications and the Rule of 20

Exceptional communication skills are needed to quickly build a good rapport with the pet owner under very stressful and emotional circumstances. From first contact by telephone to final discharge of the patient and follow-up care, each member of the critical care team must develop a caring and trusting relationship with the pet owner (client). It is important to create an open forum that includes a gentle tone of voice, body language that projects an approachable demeanor, open-ended questions when taking information, attentive listening to owner concerns, and establishing realistic medical and financial expectations. When successful, the decisions made regarding the medical care of the patient can be a shared process between the owner(s) and the critical care team. More information can be found in the Further reading list at the end of the chapter.

The Rule of 20 is a fluid and dynamic monitoring tool that can be utilized to treat any critical patient. As the knowledge pertaining to the pathophysiology of disease expands, new drugs, new treatments, additional diagnostic tools, and state-of-the-art monitoring methods can be easily inserted into the format. The information gained from the Rule of 20 provides a solid foundation for patient care, as well as for communications among staff and with clients. The Rule of 20 assists the critical care team in providing the structured, thorough, and complete evaluation needed for small animal patients with complex medical problems.

Human medicine has coined the term *hospital medicine* to describe the discipline concerned with the medical care of acutely ill hospitalized patients. Physicians whose primary professional focus is hospital medicine are called hospitalists [20]. The term

criticalist has been used in a similar capacity in veterinary medicine. The hospital medicine concept in some human studies has been associated with decreased mortality and fewer adverse events [21,22]. The Rule of 20 provides an important tool for the critical care team to facilitate reaching similar goals for the veterinary small animal ICU.

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Further reading

Silverman J, Kurtz S, Draper J. Skills for Communicating with Patients, 3rd edn. London: Radcliffe Publishing, 2013.