What to Monitor & Why

Essential parameters to monitor in the critically ill or injured patient

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"Many look, but few see."

Indications

The critically ill or injured animal is under significant physiological stress. Vigilant monitoring can reveal impending complications or adverse trends so that timely intervention can occur to reverse the situation. Technological advances and sophisticated equipment have done much to improve the ability to monitor and assess the status of the critically ill patient. However, the cornerstone to monitoring patients is serial physical examinations; they help determine which additional tests or monitoring modalities to employ for a specific patient. Information, and especially trends noted in the physical examinations, places the data generated by the precision equipment in the context of a living, breathing patient; serial physical examinations provide the framework for interpreting and reacting to the information gathered from specialized monitoring devices.

This article discusses the broad physiological categories to monitor and the tools to use. The frequency of monitoring the various parameters varies with the patient, but at least twice daily seems prudent for most parameters. Some patients will require much more intensive monitoring. While this is not an all-inclusive list of what can or should be monitored in the critically ill or injured patient, it presents the most important and most basic parameters to monitor. Much of this can be accomplished with little or no special equipment.

Parameters to Monitor

Hydration Status/Fluid Balance

In addition to the physical examination parameters of skin turgor and mucous membrane moistness, acute change in body weight is often an accurate reflection of fluid loss or gain. Dehydration is a deficit of interstitial fluid volume. Increased fluid output in the form of vomiting, urination, diarrhea, or even excessive water loss from panting should be an indicator to monitor for dehydration. A concentrated urine specific gravity in the face of IV fluid therapy may also be an indication that the patient is not hydrated. Serum sodium is a useful indicator of total body water status. A trend toward increasing serum sodium is an indicator of loss of free body water. Conversely, overhydration may be indicated by interstitial edema in the periphery (subcutaneous tissues), chemosis, or even pulmonary edema. Trends in the packed cell volume/total protein (PCV/TP) values can also indicate changes in hydration status.

Hypervolemia can also be a problem in critically ill patients. Central venous pressure is the luminal pressure of the intrathoracic vena cava. It is an estimate of actual blood volume relative to blood volume capacity and as such is a useful tool for guiding the limits of fluid therapy, especially in the face of impaired ability to excrete a fluid load due to renal insufficiency or diminished cardiac function.

Monitoring a patient's central venous pressure

Perfusion

Poor perfusion is an indicator of intravascular fluid deficit. Perfusion of vital organs can be assessed by physical examination parameters such as mucous membrane color and capillary refill time, as well as other parameters including urine output and peripheral extremity temperature. Cool mucous membranes or distal limbs may indicate poor perfusion. Pale mucous membranes could indicate anemia or peripheral vasoconstriction as an indicator of poor perfusion. Good urine output is an indicator of good perfusion of vital organs. A minimal urine output is 1 ml/kg/hr; output below this is a sign of renal or postrenal dysfunction or poor perfusion

continues

of the kidneys. Urine output can be estimated roughly by frequent bladder palpation and measurement of the weight change of disposable pads or diapers or measured accurately through the placement of an indwelling urinary catheter and closed collection system.

Although arterial blood pressure is not the only determinant of tissue perfusion, perfusion cannot occur without the presence of a minimal mean blood pressure. The minimum mean systemic arterial pressure considered necessary to ensure perfusion of vital organs such as the heart, brain, and kidneys is 50 to 60 mm Hg. Various methods of direct or indirect measurement of arterial blood pressure are available. When tissue oxygen demands are not met because perfusion is inadequate, lactic acidosis occurs. Thus, serial monitoring of blood lactate levels can help in assessing perfusion status.

Pain

The presence and degree of pain is often referred to as the fourth vital sign. Pain should be anticipated and treated preemptively or presumptively whenever possible. A recent article in *Clinician's Brief* (April 2006) provided an excellent overview of pain recognition, prevention, and treatment strategies. Care should be taken to use monitoring techniques gently and with care not to induce further discomfort or pain.

Oxygenation/Ventilation

Respiratory rate and effort can give some indication as to the ventilatory and oxygenation status of the patient. A change in respiratory rate, pattern, or effort may warrant further exploration with pulse oximetry, end-tidal CO_2, thoracic radiographs, or arterial blood gas analysis. When oxygenation/ventilation status is questionable, administer supplemental oxygen and/or positive pressure ventilation while collecting the required data to further assess the situation. Mucous membrane color is a late indicator of hypoxemia. For visual detection of cyanosis, 5 mg/dl of deoxygenated hemoglobin must be present.

Metabolic

Abnormalities in blood sugar and electrolytes as well as acid–base derangements occur with frequency in the critically ill patient. These values should be checked at least once daily to ensure appropriate adjustments in fluid therapy are made when necessary.

Indirect blood pressure assessment

Renal

Azotemia is common in critical care patients. Renal failure can be a primary problem or a secondary complication. It is essential to keep close tabs on urine production, hydration, and perfusion parameters to avoid this potentially devastating complication. Although placement of a urinary catheter with closed collection system involves some risk of introduction of an iatrogenic urinary tract infection, the benefits of being able to closely quantify the urine output and rapidly identify changes may outweigh the risk of infection.

Coagulation

Deficiencies in either primary or secondary coagulation, or both, are common sequelae to serious illness. Monitor for oozing from venipuncture or catheter sites, petechiation, ecchymosis, melena, hematemesis, and declining platelet count and/or PCV. Serial blood smears to evaluate platelet numbers are useful for early identification of impending disseminated intravascular coagulation. Activated coagulation time (ACT) tubes as well as in-house, point-of-care machines are available to monitor coagulation parameters. Buccal mucosal bleeding time devices are readily available to assess platelet function in patients with suspected deficits.

Nutrition

Critically ill patients need good nutrition to adequately meet the body's needs for tissue repair and regeneration. Body weight (BW) as well as the length of time that the patient has gone without eating can be used as indicators of the need for nutritional support. Patients who have lost more than 5% of their body weight, who have not eaten, or are expected not to eat for 3 or more days are candidates for timely nutritional support, which will help avoid protein/calorie malnutrition, delayed recovery, or other adverse effects of starvation/catabolic state. Many advocate the initiation of nutritional support as early as feasible during recovery from illness or injury.

A closed urinary collection system increases the risk of infection but its benefits often outweigh this risk in the critical care setting.

Resting energy requirement (RER) can be calculated from the following formulas:

Patients greater than 2 kg and less than 45 kg

$$RER = BW(kg) \times 30 + 70 \text{ kcal/day}$$

Patients outside of the above range

$$RER = 70 \times BW(kg)^{0.75} \text{ kcal/day}$$

Evidence has shown few patients actually need more calories than those provided by the RER; multiplication by an illness energy requirement (IER) is rarely necessary.

A patient-side coagulation analyzer

Immune System/Infection Control

Critically ill patients often have infection as a component of their presenting disease process. Additionally, their immune systems are compromised by the stress of their illnesses and by the invasive nature of many treatments (surgery, IV catheters and other tubes, monitoring devices). It is important to check catheter and wound sites daily for evidence of infection or inflammation. It is also important to monitor trends in body temperature and white blood cell counts. When a patient's temperature has been 100.5°F for 3 days and is suddenly 102.5°F, further investigation is required for an underlying cause of the change, even though the new temperature is in the normal range: the trend is more important than the actual value. Appropriate antimicrobial therapy should be instituted when indicated and modified by culture and sensitivity results whenever possible. All caretakers of critically ill patients must adhere to strict rules of hygiene such as hand washing, sterile techniques, and gloves when appropriate to avoid introduction of an iatrogenic infection, or transfer of infectious agents from patient to patient.

Follow-up

Monitoring is an ongoing process as the patient recovers from illness or injury. As mentioned before, trends are often more important than the actual value of a parameter. Accurate recording of findings in an organized and retrievable way in the medical record is essential. This is especially important in this era of 24-hour care and frequent referrals that can result in many veterinarians caring for a single patient over the course of an illness.

A vital signs monitor makes monitoring constant and easier but is not necessary to provide excellent patient assessment. There is no substitute for the eyes, ears, and hands of the clinician.

Relative Cost

The sky is the limit on the amount a veterinary practice owner could spend on monitoring equipment. However, the most important monitors—the eyes, ears, and hands of the veterinarians and technicians that care for and assess the critically ill pets—provide immense value at relatively small cost.