

First Aid, Transport, Triage and CPR for Technicians

Part 3 – Vital Signs – Heart rate and rhythm, Perfusion Parameters

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HEART RATE AND RHYTHM

Rate

The function of the heart is to pump blood to the tissues. The amount of blood pumped by the heart is termed cardiac output and is dependent on the rate and force of contraction. The force of the contraction results from stretch of the myocardium from ventricular filling. The amount of venous blood returned to the heart (called preload) determines ventricular filling. Should the venous return be reduced due to hemorrhage or intravascular fluid loss (e.g. third spacing into the gut, uterus, peritoneum), the heart responds by increasing heart rate (tachycardia) and force of contraction (inotropy) through sympathetic stimulation. However, sympathetic induced tachycardia and inotropy can occur with stress, pain, elevated temperature, and drugs unrelated to intravascular volume loss.

An increase in heart rate and contractility will increase the force pushing the blood to the tissues and the volume being pumped. Sinus tachycardia can be normal, or associated with shock, stress, excitement, fever, and hyperthyroidism. However, when the heart rate increases above a critical level, not only does the heart muscle exhaust its energy supply, but coronary perfusion decreases causing myocardial hypoxia. Cardiac arrhythmias and myocardial failure can result, leading to systemic hypoxia and organ failure.

A decreased heart rate (bradycardia) can lead to a decreased cardiac output. Causes of bradycardia include hypothermia, metabolic disorders (such as hyperkalemia, hypoglycemia and hypothyroidism), and parasympathetic (vagal) stimulation. Parasympathetic stimulation can occur with brain, pulmonary and gastrointestinal diseases, diseased sinoatrial node disease, or the administration of drugs that either stimulate the parasympathetic nervous system or decrease the sympathetic system. Heart rates that fall below a critical level can lead to tissue hypoxia, organ failure and death.

Rhythm

The conduction system supplies the electrical stimulation for contraction of the heart. The rate at which the conduction system fires determines the heart rate, as long as the muscles responds to the electrical stimulation. The rhythm of the contractions is dependent upon the route of the electrical impulse through the nerve fibers in the heart. A normal impulse starts at the sinoatrial node in the right atrium, travels through the atria to the atrioventricular node (at the junction of the atria and ventricles), to the Bundle of His and ventricular nerves (Purkinje fibers). This pathway provides a normal rhythm.

An arrhythmia is defined as an irregularity of the heart beat and can be detected by simultaneously auscultating the heart and palpating a peripheral pulse. When the ventricular contraction has not been successful in forcefully propelling blood to the periphery, a pulse deficit is detected. An arrhythmia can also be defined as a heart beat that is abnormally fast or slow. An abnormal conduction system or diseased heart muscle can cause an arrhythmia.

When an arrhythmia is suspected, the veterinarian is alerted and an electrocardiogram (EKG) is done. Thoracic radiographs and echocardiography may be required to better define muffled heart sounds. Not all arrhythmias are pathological. When the ECG has a P wave associated with the majority of QRS complexes and the QRS complexes are normal in width, the rhythm is termed supraventricular. Sinus arrhythmia is a fluctuation in the heart rate with respiration, decreasing with expiration and increasing with inspiration and is considered normal in the dog. When the ECG shows QRS waves that are wide and bizarre, not associated with P waves, this is termed a ventricular rhythm. Supraventricular and ventricular arrhythmias can both be subdivided according to rate, into normal rate, bradyarrhythmias (or those that are below normal rates) or (those that are faster than the normal rates) or tachyarrhythmias.

Assessment

The technician should listen to the heart by placing the stethoscope over the left and right side of the thorax at the 4-6th intercostal space while palpating the pulse. Pericardial fluid, pleural air or fluid, severe hypovolemia, or herniated abdominal organs will cause muffled heart sounds. Tachycardia, bradycardia, muffled heart sounds, and pulse deficits require immediate attention by the veterinary team.

A continuous ECG and blood pressure measurements may be necessary to detect changes in rate and rhythm and their effects on perfusion. All vomiting animals require close monitoring because collapse may occur due to severe bradycardia from increased vagal tone. Should an arrhythmia be determined to

cause impaired perfusion, oxygen supplementation is warranted while the veterinary team is treating the arrhythmia.

PERFUSION PARAMETERS

Pulse strength and quality, jugular distension, mucous membrane color (MM), capillary refill time (CRT), and body temperature are parameters that help evaluate how well the animal is providing blood flow (perfusing) to peripheral tissues.

Pulse

Blood pumped into the aorta during ventricular contraction creates a fluid wave that travels from the heart to the peripheral arteries. This wave is called a pulse. The character of the pulse depends on stroke volume, heart rate and force of ejection as well as vascular tone. Evaluation of the pulse strength is based on the difference between the systolic and diastolic pressure called the pulse pressure. A normal pulse pressure makes the pulse easily palpated and strong. When the difference is wide, the pulse will be bounding (hyperkinetic). Causes of hyperkinetic pulses include fever, hyperthyroidism, patent ductus arteriosus and early, compensatory stages of shock. When the difference is small or the time to maximum systolic pressure is prolonged, the pulse feels weak (hypokinetic). Causes of hypokinetic pulses include disease conditions that have a decreased cardiac output (e.g. late stages of shock, heart failure, and arrhythmias).

Assessment

Pulses are palpated by lightly placing the index and middle fingers on the part of the body where an artery crosses over bone or firm tissue. The most common pulse points assessed are the femoral and dorsal pedal arteries. In cats both femoral pulses should be assessed simultaneously to determine if there is some degree of flow obstruction as seen with saddle thrombus.

Any changes in pulse quality should be reported to the veterinarian. Bounding pulses may reflect pain, fever or early shock and will require intervention with pain medication and fluid replacement by the veterinary team. Weak pulses are cause immediate concern and warrant aggressive measures to improve cardiac output (e.g. IV fluids for shock, appropriate cardiac medications for heart failure).

Jugular Vein Distension

Significant increased in central venous pressure may be recognized clinically by jugular venous *distension*. Persistent jugular vein distention occurs with right congestive heart failure secondary to high right filling pressures, external compression of the cranial vena cava (such as occurs with pericardial effusion/tamponade, tension pneumomediastinum, tension pneumothorax or right side heart mass), and jugular vein thrombosis. Jugular veins should not be distended when the patient is standing with the head in normal position parallel to the floor. The presence of jugular pulsations higher than one third of the way up the neck is abnormal.

Mucous Membrane Color and Capillary Refill Time

The normal pink color of the non-pigmented membranes is dependent upon having an appropriate blood hemoglobin concentration, tissue oxygen tension and peripheral capillary blood flow. Capillary refill time (CRT) is a result of blood flow to the capillary beds of the membranes. This flow is dependent upon cardiac output and the vascular tone.

Assessment

Although mucous membrane color is most commonly assessed at the gums, the conjunctiva of the eye and the membranes of the vulva and penis can also be used. The normal color of a non-pigmented membrane is pink. To obtain a CRT, pressure is applied by the index finger to a nonpigmented area of the mucous membranes and then released. The time for color to return to the blanched area is recorded as the CRT. Normal values are 1 to 2 seconds. A prolonged CRT (>2 seconds) suggests poor peripheral perfusion (e.g. later stage of shock, severe vasodilation or vasoconstriction, pericardial effusion, heart failure). A rapid CRT (<1 second) can be due to anxiety, compensatory shock, fever, and pain.

Intervention

Abnormal MM color or CRT should be brought to the attention of the veterinarian immediately (see Table 1). Pale gums, with prolonged capillary refill time necessitate oxygen administration and rapid search for the underlying cause. The veterinary technician should be prepared to measure the blood pressure, measure the central venous pressure, perform an ECG, or determine the packed cell volume while recording the data. Aggressive fluid resuscitation might be required and the veterinary nurse should be prepared for rapid intervention

Table 1. Interpretation of Mucous membrane Color

<i>COLOR</i>	<i>INTERPRETATION</i>	<i>CAUSES</i>
Pink	Normal	Adequate perfusion & oxygenation at the periphery
Pale	Decreased Hb*, poor perfusion, vasoconstriction	Anemia, shock vasopressors
Blue	Cyanosis, inadequate oxygenation	Hypoxemia
Brick Red	Hyperdynamic perfusion, vasodilation	Early shock, sepsis, fever, SIRS***
Icteric	Bilirubin accumulation	Hepatic/biliary disorder, hemolysis
Brown	Methemoglobinemia	Acetaminophen toxicity
Petechia/ Ecchymosis	Coagulation disorder	Platelet disorder, DIC**, factor deficiencies

* Hemoglobin concentration

** Disseminated intravascular coagulation

*** Systemic inflammatory response syndrome