

Peer Reviewed

# Reading Electrocardiograms

The ECG is a record of the average electrical potential generated in the heart muscle at the body's surface.

The electrocardiograph amplifies and filters these small electrical signals and graphs this signal in voltage and time. These electrical signals are created by intracellular and extracellular ionic gradients that move across semipermeable membranes and result in cellular transmembrane action potentials. The action potentials occur in myocardial and autonomic tissues and vary on the basis of inherent characteristics of the tissue.

With continuous practice, reading ECGs can become a rapid and easy process in most cases. This article is meant only as a guide for stepwise assessment of ECGs.

## INDICATIONS

The ECG is primarily used to detect and assess the normalcy of the heart's rhythm or to diagnose or monitor patients with arrhythmias. Historically, ECGs have also been used as an adjunct to detect cardiac chamber enlargement. However, echocardiography showed that ECGs are neither sensitive nor specific for identifying chamber enlargement; using them for this purpose is no longer recommended.

Other indications include using ECGs to assess acute antiarrhythmic and other cardiac drug therapy, to evaluate electrolyte and acid-base disturbances, and as part of a complete cardiovascular examination.

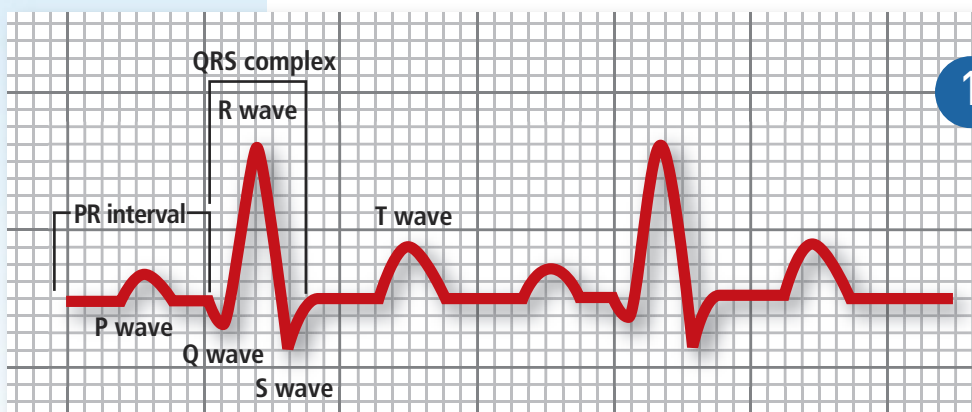


Figure depicting the various waveforms and intervals seen in an ECG

## CONSIDERATIONS

### Waveforms & Intervals

When reading an ECG, one should be familiar with normal variants in the species being examined. The recorded ECG waveforms and intervals that should be measured in the standard frontal plane leads (leads I, II, III, aVR, aVL, aVF) include the following (Figure 1):

- The **P wave** indicates atrial depolarization.
- This is followed by the **PR interval**, which is measured from the start of the P wave to the start of the QRS complex. It indicates the time of conduction from the sinoatrial node to the ventricles. Time in the atrioventricular node represents 75% of this interval.
- The **QRS** is a complex of 3 waveforms that represent ventricular depolarization. All 3 waves may not be present at a given time.
- The **Q wave** is the first negative deflection.
- The **R wave** is the first positive deflection after the P wave. It is typically the predominant waveform in left-facing leads (I, II, aVF, aVL, CV6LL, CV6LU).
- The **S wave** is the first negative deflection after a positive deflection.
- The last normal waveform present is the **T wave**, which represents ventricular repolarization and can be altered with electrolyte abnormalities, such as hyperkalemia.

Abnormalities in the height or duration of the QRS complex can indicate abnormal conduction or chamber enlargement.

ECG = electrocardiogram

## EVALUATION

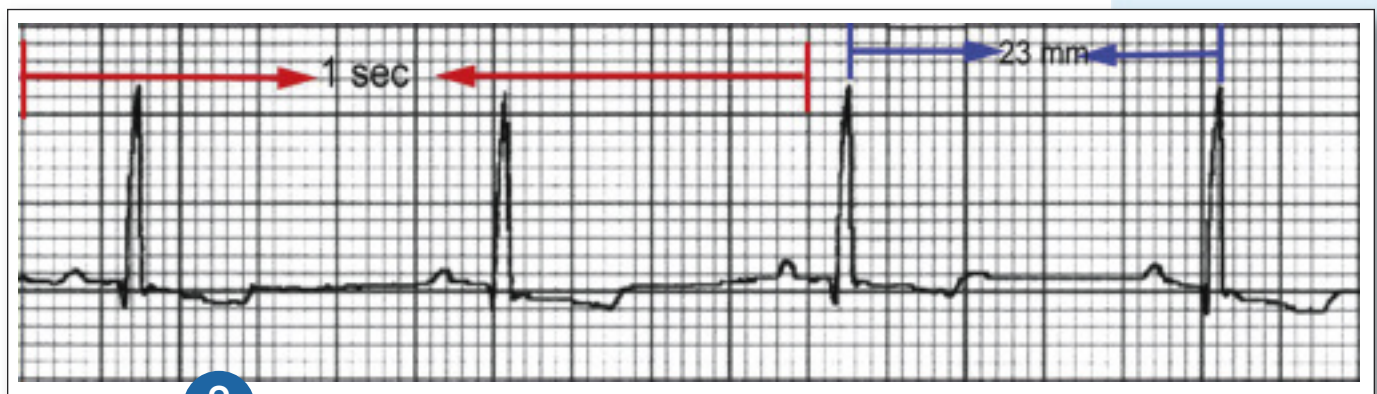
### The Basics

- **Paper speed**—We usually set our paper speed to 50 mm/sec or 25 mm/sec.
- **Sensitivity**—We usually keep sensitivity standard (10 mm/mV). However, the sensitivity can be decreased to half (5 mm/mV) when complexes are too large or doubled (20 mm/mV) when complexes are too small. Many machines use an autoscale function, however, to adjust the sensitivities, and these should be noted on the readout to allow assessment of amplitude of the ECG complexes.
- **Leads**—Note which leads are provided. Standard lead II can be used for rhythm analysis.

### Calculate Heart Rate (Figure 2)

- **Instantaneous heart rate calculation** is a convenient method because it is fast and can be used to calculate the rate of arrhythmias of short duration. However, it is inaccurate with irregular rhythms. To perform this count, take the number of millimeters between 2 consecutive R waves and divide this number into 3000 (50 mm/sec) or 1500 (25 mm/sec).
- For the **standard heart rate calculation**, count the number of R waves in a given period of time and multiply by an appropriate integer to equal 60 seconds (ie, 3 seconds  $\times$  20 or 6 seconds  $\times$  10). This calculation is helpful with gradual rate changes over time but tends to be inaccurate for very short-lasting arrhythmias.

CONTINUES



Heart rate calculation (paper speed = 50 mm/sec, sensitivity = 10 mm/mV): Instantaneous heart rate = 130 beats/min (3000/23); Standard heart rate = 120 beats/min (3  $\times$  60)

**DETERMINE OVERALL RHYTHM**

- With a regular rhythm, the RR interval, the time elapsed between 2 consecutive R waves, does not vary much (< 10%).
- Irregular rhythms display variation in the RR interval.
- Determine whether there is a pattern (dubbed “regularly irregular”) to the variation of the RR interval. This usually indicates a sinus arrhythmia, which is common and considered normal in dogs.
- If no pattern can be ascribed to the variation in the RR interval, this may indicate advanced arrhythmias, such as atrial fibrillation (depending on the presence of other criteria).

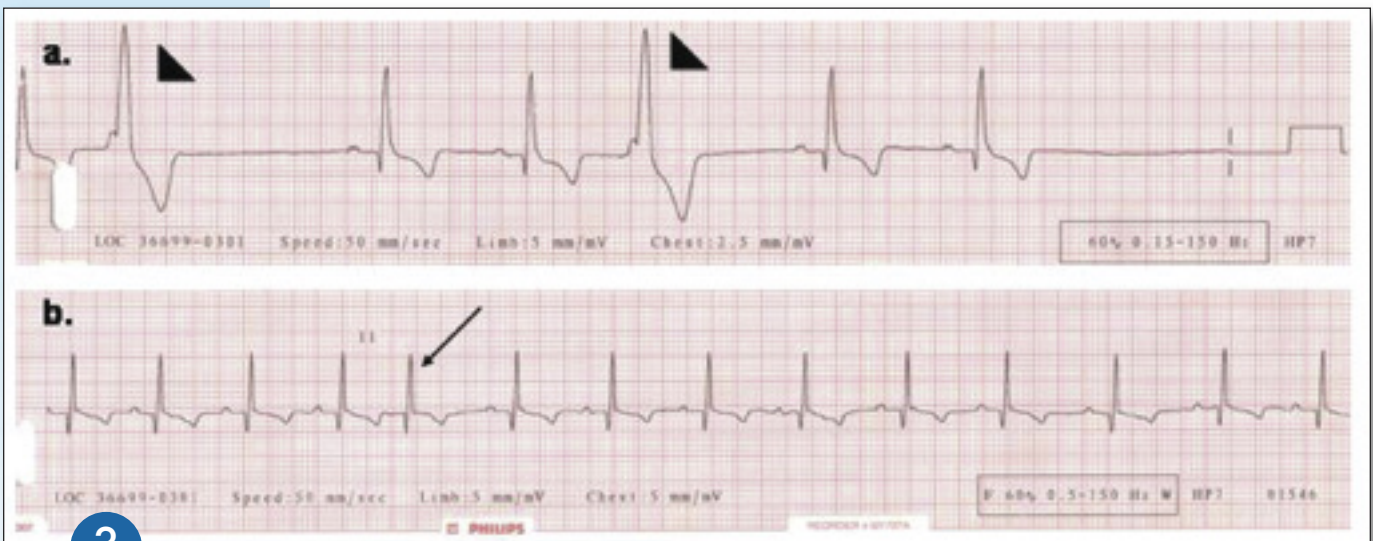
**IDENTIFY SPECIFIC WAVEFORMS, TIMING, & MORPHOLOGY**

- Assess whether the P wave, QRS complex, and T wave are present and related to each other by appropriately timed intervals.
- Answering the questions “Is there a P wave for every QRS complex and a QRS complex for every P wave?” and “Is there an appropriate relationship based on the PR interval?” may help make a diagnosis. For example, if a P

wave without a QRS complex is present, the tentative diagnosis is second-degree atrioventricular block. This step can be difficult at times; however, here are some other caveats that may help:

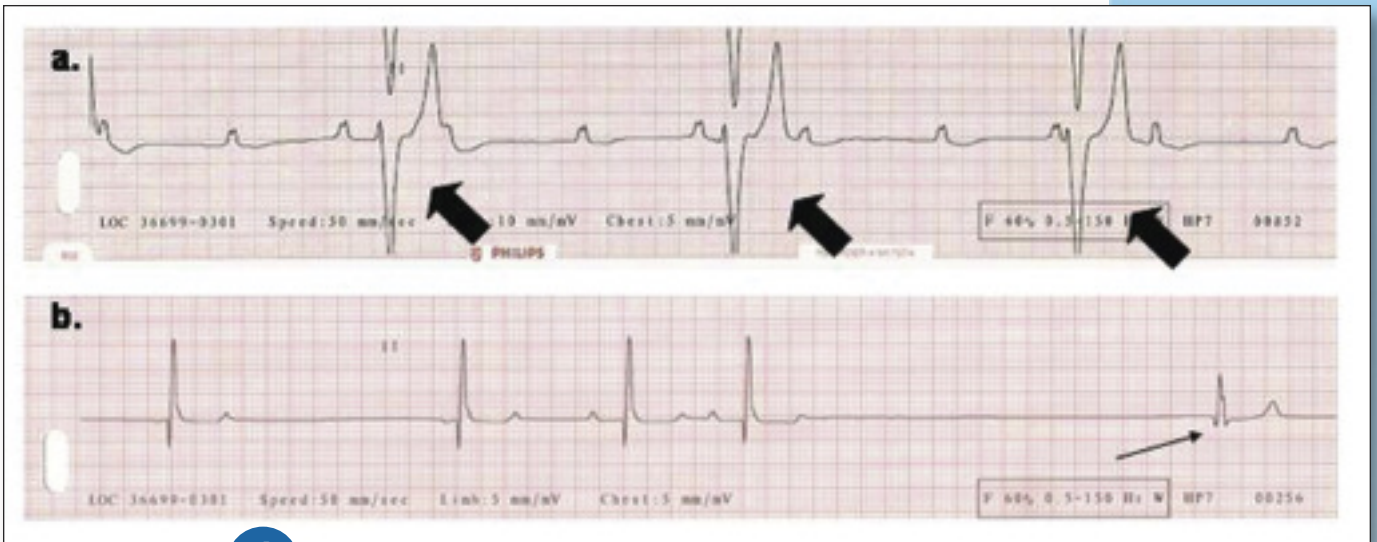
- There must be a T wave after every QRS complex, a feature that helps identify the QRS complex (sometimes working backward helps).
- P waves generally look the same except in the case of atrial premature contractions and respiratory sinus arrhythmia.
- P waves and T waves may overlap in atrial tachycardias.
- Rule out the possibility that artifacts are interfering with the readout. These are usually related to patient movement, electrical interference, or poor electrode contact with the patient.
- Note whether there are any QRS complexes that appear earlier than expected (premature) or later than expected (escape rhythms) (Figures 3 and 4). The origin of these complexes can generally be discerned (with some exceptions) by the QRS morphology.

CONTINUES



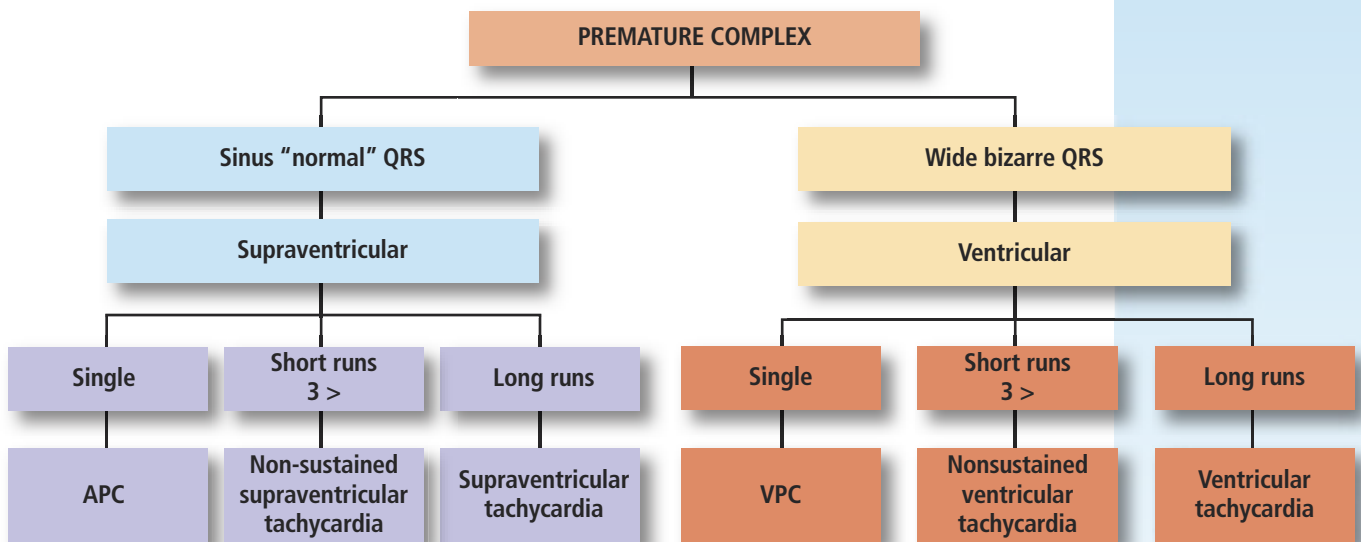
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Lead II rhythm strips: Ventricular premature complexes (VPCs)—Note the wide and bizarre nature of the complexes that originate earlier than expected on the basis of the RR interval of the more normal (narrow) QRS complexes (arrowheads) (a); atrial premature complex (APC)—Note the fifth narrow QRS (arrow) that enters the rhythm earlier than expected (b). Also note in this APC that the P wave preceding this complex has a different morphology than P waves associated with the normal sinus rhythm.



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Lead II rhythm strips: Third-degree atrioventricular blockade with 3 ventricular escape rhythms (**thick arrows**) (a); sinus pause with a junctional escape beat at the end of the strip (**thin arrow**) (b).



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Chart demonstrating nomenclature applied to premature complexes

APC = atrial premature complexes; VPC = ventricular premature complexes



- **Supraventricular (atrial or junctional) complexes** demonstrate a normal, usually narrow, QRS morphology, and those originating in the ventricles typically appear wide and bizarre.
- **Premature rhythms**, depending on frequency and origin, can result in reduced stroke volume and thus may compromise cardiac output. As a result they should be further assessed. **Figure 5** provides some basic nomenclature for premature complexes.
- **Escape rhythms** are life-saving depolarizations that occur after long delays in the normal beat and always occur secondary to some primary rhythm disturbance, such as sinus arrest or third-degree atrioventricular block. Thus, by definition escape rhythms are never a diagnosis by themselves. They can originate from junctional (nodal) or ventricular Purkinje cells.

Following these simplified guidelines regularly when analyzing an ECG will help create a process for interpretation.

### ADVANTAGES

ECGs are easy to obtain. The ability to record and read an ECG prevents treatment delays that could occur if a patient

is sent to a secondary facility or there is a wait for interpretation from secondary and tertiary sources.

### DISADVANTAGES

Surface ECG may not detect infrequent arrhythmias if it is not recorded for sufficient periods of time.

### ECONOMIC IMPACT

Minimal—ECGs need to be obtained on patients demonstrating abnormal rhythm on auscultation and those with signs potentially related to abnormal heart rhythms.

### RELIABILITY OF RESULTS

As stated previously, the ECG is highly reliable for evaluating the heart's rhythm and monitoring for disturbances in rhythm. It is not as sensitive for detecting chamber enlargement.

See Aids & Resources, back page, for references & suggested reading.

ECG = electrocardiogram

NADA #141-305, Approved by FDA.

## ORBAX® Oral Suspension (orbifloxacin)

For Oral Use in Cats Only.

Federal law prohibits the extralabel use of this drug in food-producing animals

**CAUTION:** Federal law restricts this drug to use by or on the order of a licensed veterinarian.

**DESCRIPTION:** Orbifloxacin is a synthetic broad-spectrum antibacterial agent from the class of fluoroquinolone carboxylic acid derivatives. Orbifloxacin is the international nonproprietary name for 1-cyclopropyl-5,6,8-trifluoro-1,4-dihydro-7-(*cis*-3,5-dimethyl-1-piperazinyl)-4-oxoquinoline-3-carboxylic acid. The chemical formula for orbifloxacin is C<sub>23</sub>H<sub>26</sub>F<sub>3</sub>N<sub>2</sub>O<sub>3</sub> and its molecular weight is 395.38. The compound is slightly soluble in water; however, solubility increases in both acidic and alkaline conditions. The compound has two dissociation constants (pKa's): 5.95 and 9.01. **ORBAX® Oral Suspension** is a mild flavored antibiotic suspension containing 30 mg/mL of orbifloxacin and sorbic acid as a preservative.

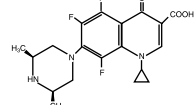


Figure 1. Chemical structure of orbifloxacin.

**INDICATIONS:** **ORBAX® Oral Suspension** is indicated for the treatment of skin infections (wounds and abscesses) in cats caused by susceptible strains of *Staphylococcus aureus*, *Escherichia coli*, and *Pasteurella multocida*.

**DOSAGE AND ADMINISTRATION:** **Shake Well Before Use.** BEFORE INITIAL USE, remove the cap and insert the syringe adaptor by pressing firmly into top of bottle. Insert the syringe tip into the adaptor opening and invert the bottle. Withdraw the required amount of medication with the calibrated syringe. After use, replace cap, leaving adaptor in the bottle, and rinse the syringe with water. In the cat, **ORBAX® Oral Suspension** and **ORBAX® (orbifloxacin) Tablets** are not bioequivalent. On a mg/kg basis, **ORBAX® Oral Suspension** provides lower and more variable plasma levels of orbifloxacin than **ORBAX® (orbifloxacin) Tablets** (See Clinical Pharmacology and Precautions). The dose of **ORBAX® Oral Suspension** in the cat is 3.4 mg/lb (7.5 mg/kg) of body weight administered once daily. DO NOT EXCEED 3.4 mg/lb (7.5 mg/kg) BODY WEIGHT PER DAY IN CATS. **ORBAX® Oral Suspension** should be given for two (2) to three (3) days beyond the cessation of clinical signs. Antibiotic susceptibility of the pathogenic organism(s) should be determined prior to use of this preparation. Therapy with **ORBAX® Oral Suspension** may be initiated before results of these tests are known. Once results become available, continue with appropriate therapy. If no improvement is seen within 3 to 4 days, the diagnosis should be re-evaluated and a different course of therapy considered.

**CONTRAINDICATIONS:** Orbifloxacin and other quinolones have been shown to cause arthropathy in immature animals of most species tested, the dog being particularly sensitive to this side effect. Orbifloxacin is contraindicated in immature dogs during the rapid growth phase (between 2 and 8 months of age in small and medium-sized breeds, and up to 18 months of age in large and giant breeds). Orbifloxacin is contraindicated in cats known to be hypersensitive to quinolones.

**HUMAN WARNING:** For use in animals only. Keep out of the reach of children. Individuals with a history of hypersensitivity to quinolones should avoid this product. In humans, there is a risk of user photosensitization within a few hours after excessive exposure to quinolones. If excessive accidental exposure occurs, avoid direct sunlight. Avoid contact with eyes. In case of contact, immediately flush eyes with copious amounts of water for 15 minutes. In case of dermal contact, wash skin with soap and water. Consult a physician if irritation persists following ocular or dermal exposure.

**PRECAUTIONS:** Prescribing antibacterial drugs in the absence of a proven or strongly suspected bacterial infection is unlikely to provide benefit to treated animals and may increase the risk of the development of drug-resistant animal pathogens. The use of fluoroquinolones in cats has been reported to adversely affect the retina. Such products should be used with caution in cats. Blindness has also been reported post-approval in cats. In some cases, blindness has been temporary. DO NOT EXCEED 3.4 mg/lb (7.5 mg/kg) BODY WEIGHT PER DAY IN CATS. If higher blood levels of orbifloxacin are needed, **ORBAX® (orbifloxacin) Tablets** should be used at a dose of 2.3-3.4 mg/lb (5.0-7.5 mg/kg). On a mg/kg basis, **ORBAX® (orbifloxacin) Tablets** provide higher and less variable plasma levels of orbifloxacin than **ORBAX® Oral Suspension**. Quinolones should be used with caution in animals with known or suspected central nervous system (CNS) disorders. In such animals, quinolones have, in rare instances, been associated with CNS stimulation, which may lead to convulsive seizures. Quinolones have been shown to produce erosions of cartilage of weight-bearing joints and other signs of arthropathy in immature animals of various species. The safety of orbifloxacin in animals that are used for breeding or that are pregnant and/or lactating has not been demonstrated.

**DRUG INTERACTIONS:** Compounds (eg, sulfonamides, antacids, and multivitamins) containing divalent and trivalent cations (eg, iron, aluminum, calcium, magnesium, and zinc) may substantially interfere with the absorption of quinolones resulting in a decrease in product bioavailability. Therefore, the concomitant oral administration of quinolones with foods, supplements, or other preparations containing these compounds should be avoided. The dosage of theophylline should be reduced when used concurrently with fluoroquinolones. Cimetidine has been shown to interfere with the metabolism of fluoroquinolones and should be used with care when used concurrently. Concurrent use of fluoroquinolones with oral cyclosporine is contraindicated. Concurrent administration of fluoroquinolones may increase the action of oral anticoagulants.

**ADVERSE REACTIONS:** In a field study, when the tablet formulation of orbifloxacin was administered at 2.5 mg/kg/day, no drug-related adverse reactions were reported. In a foreign field study using the oral suspension at 7.5 mg/kg/day, vomiting was reported for **ORBAX® Oral Suspension** and the comparator. Post Approval Experience with **ORBAX® (orbifloxacin) Tablets** (Rev. 2010): *The following adverse events are based on post-approval adverse drug experience reporting with ORBAX® Tablets. Not all adverse reactions are reported to FDA CVM. It is not always possible to reliably estimate the adverse event frequency or establish a causal relationship to product exposure using this data. The following adverse events are listed in decreasing order of reporting frequency:* **CAT:** Blindness, mydriasis, anorexia, ataxia, depression/lethargy, vomiting, convulsions, abnormal retina, hypersalivation. In some cases, blindness has been temporary. *For a complete listing of adverse reactions for ORBAX® (orbifloxacin) Tablets reported to the CVM see: <http://www.fda.gov/AnimalVeterinary/SafetyHealth/ProductSafetyInformation/ucm055394.html>. For technical assistance or to report a suspected adverse reaction call 1-800-224-5318.*

**PALATABILITY:** In a field palatability study, conducted in 101 cats, **ORBAX® Oral Suspension** was accepted by 95% of cats.

**STORAGE CONDITIONS:** Store between 2°C and 25°C (36°F and 77°F). **ORBAX® Oral Suspension** does not require refrigeration. Shake well before use. Store upright.

**HOW SUPPLIED:** **ORBAX® Oral Suspension** is supplied in a sealed bottle with a 20 mL deliverable volume.

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Made in Friesoythe, Germany  
Intervet Inc. January, 2010

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