CATCHER 311V/321V

StarCare Animals ECG and Diagnostic Statements

Veterinarian Reference Manual

SCI-V-202409-002

STARCARE In care of your ST & AR | animals

CONTENT

Chapter 1
Preamble

Thank you for choosing StarCare Animals products and for your trust in our services!

Pets are cherished members of the family, and like humans, cardiovascular diseases in cats and dogs pose serious threats to their health and longevity. Research indicates that 1 in 10 dogs and 1.5 out of 10 cats are at risk of heart disease [1]. This risk increases with age, making regular heart health examinations, such as ECGs, crucial to catch potential heart issues early.

StarCare Animals is dedicated to solving pet health challenges by developing high-quality equipment for animal ECG examinations. Our veterinary ECG diagnostic systems, along with the reports they generate, maintain the same high standards as human medical devices and software.

Our products are designed to enhance the efficiency and accuracy of veterinary clinical work, empowering veterinary professionals and pet owners to diagnose, treat, and prevent heart health problems earlier, ensuring that pets can live longer, healthier lives.

[1] https://www.purinainstitute.com/science-of-nutrition/transforming-heart-health/cardiac-conditions

Chapter 2
Brief Description and Intended Use

This user manual introduces the principles of pet ECG examination using StarCare Animals products, including basic knowledge of pet ECGs and the algorithms used for computer-based diagnosis and recognition.

The manual is intended primarily for veterinarians, but also for nurses and technicians who increasingly play vital roles in using pet ECG devices.

To promote the widespread application of pet ECGs and stimulate interest in in-depth research, this manual offers concise descriptions and guidance for easy understanding.

Note
The information in this guide is subject to change without prior notice.

Intended Use

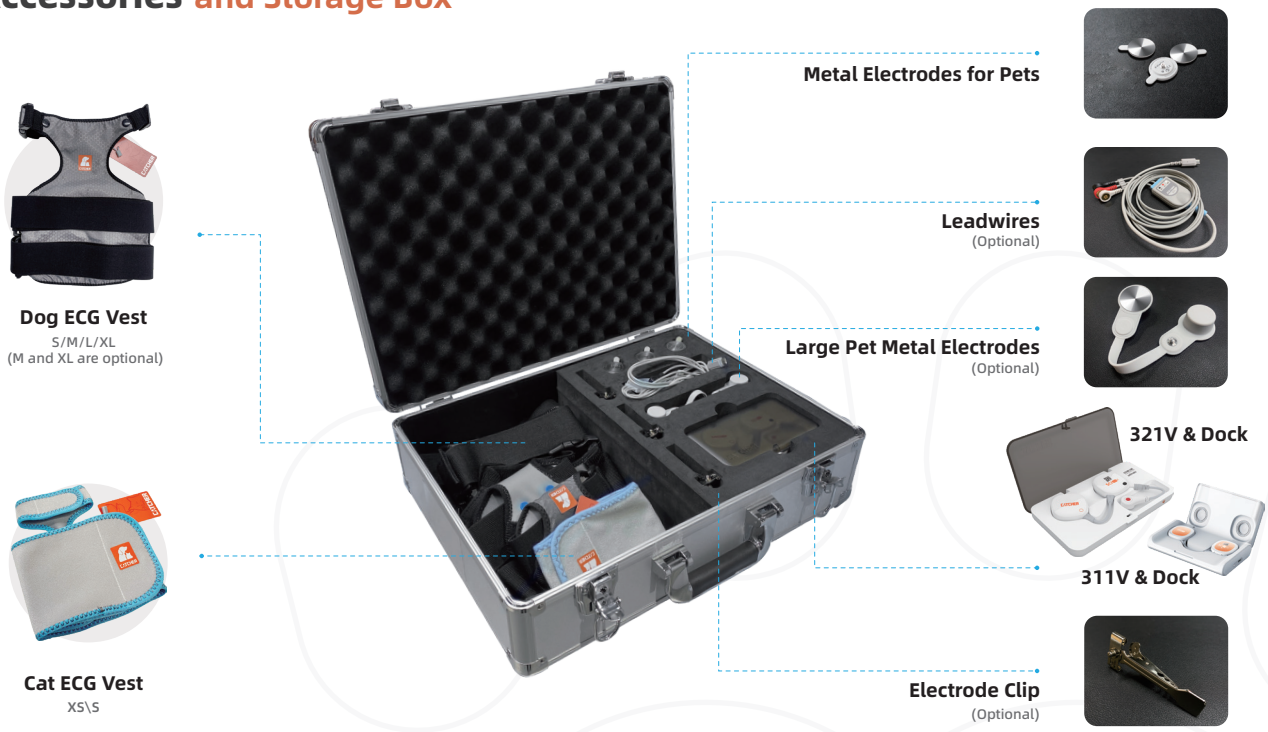
This product is suitable for dogs and cats weighing between 2-120 lbs. (or 1-55 kg) and is designed for the collection, recording, automatic analysis, and manual review of single-lead Holter ECG, as well as 6-lead resting and Holter ECGs.

Chapter 3
Product Introduction

StarCare Animals provides the following veterinary ECG products:

- Wearable devices: 311V and 321V.
- Various-sized ECG vests for cats and dogs, electrode sensors, lead wires, charging and transmission dock, electrode clips, and storage box (see figure below).
- StarCare Vets app software. [Note]
- Software workstation (aECGMap VET) [Note] equipped with analysis algorithms and cloud server connectivity.

Accessories and Storage Box



Note

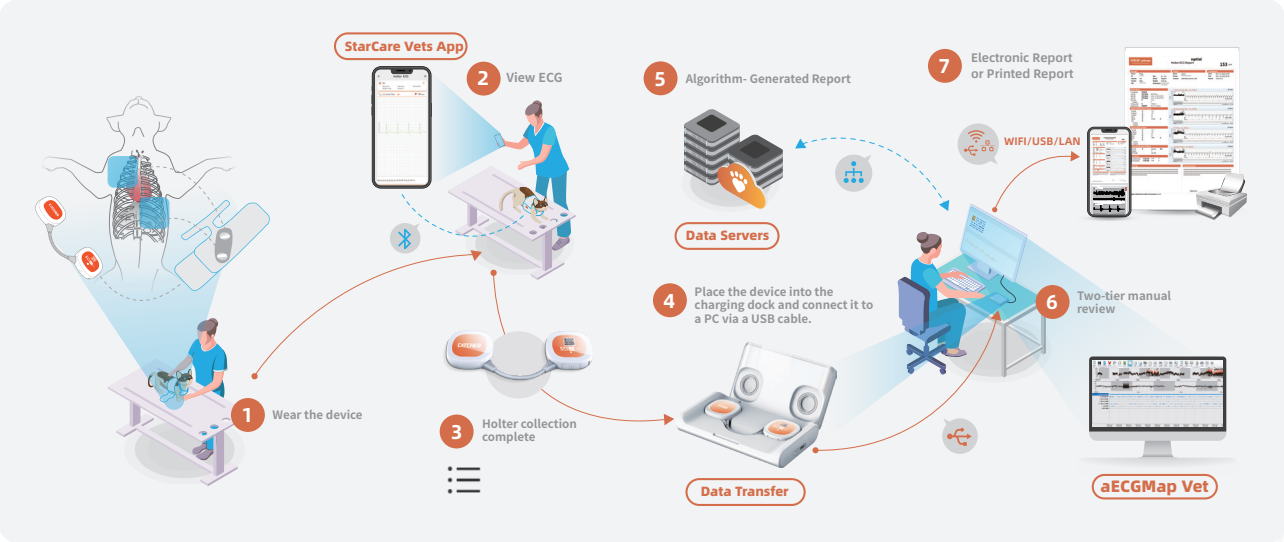
Before getting started, please download the "StarCare Vets" app on your mobile device (smartphone, tablet, etc.) . Additionally, to access the Holter ECG function, you'll need to download and install the desktop software "aECGMap V Lite" on your computer. An institutional account is required for both the app and the PC software, and a backend setup is necessary. For assistance with setting up your institution-specific username and initial password, please reach out to your distributor or agent. Once the setup is complete, you can log in and begin using the system.

Additionally, StarCare Animals' clinical team offers interpretation and review services for pet ECGs.

This chapter provides a detailed overview of the application scenarios for the wearable devices and outlines the analysis algorithms for resting ECG and Holter ECG, the ECG analysis workflows, and the process of diagnostic report generation.

3.1 Wearable Holter CATCHER 311V

The CATCHER 311V is a wearable, single-lead device designed for Holter monitoring. The wearable vests are tailored to different sizes of cats and dogs, minimizing stress and accurately capturing ECG signals, especially during pet activities, to ensure high-quality ECG waveforms.



Operation Process for 311V:

① Wearable Devices: Follow the video instructions in the app's "**How-To Video**" to properly apply the sensors and device to your pet.

② View ECG: Use the "StarCare Vets" app to link the device's serial number and view the single-lead ECG to check the wearing status **[Note]**. In "**Select Test**," select "**Holter Monitoring**" and set or modify patient information. Previously saved information can be accessed via the list icon ☰ in the upper right corner. Choose a recording duration of 1, 2, or 3 days and select "**Save.**"

③ Holter Collection Complete: Remove the device once the recording duration is reached or at any desired time (≥30 min).

④ Data Transfer: Place the device into the charging dock and connect it to a PC via a USB cable.

⑤ Algorithm-Generated Report: The computer software analyzes the uploaded ECG waveform and generates an preliminary report.

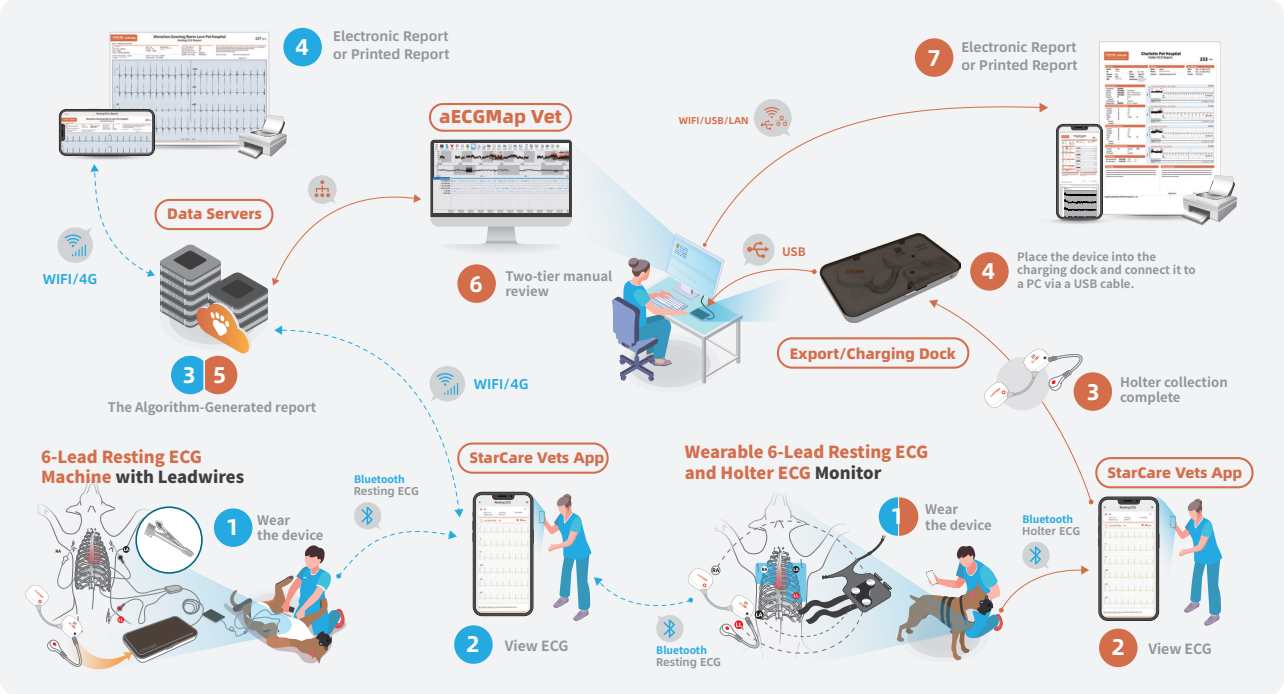
⑥ Two-Tier Manual Review: Using the aECGMap Vet software, clinical personnel review and modify the algorithm's results.

⑦ Generate Holter ECG Report: The report can be generated in both electronic and printed formats.

> **Note**
> The app does not need to remain open continuously during Holter ECG recording, but it can be used for real-time monitoring if necessary.

3.2 Wearable Holter Plus Resting ECG CATCHER 321V

The CATCHER 321V is a 6-lead device suitable for both resting and Holter ECG examinations. Sensors can be worn using a vest or traditional lead wires.



Operation Process for 321V:

1. 6-lead Resting ECG (Steps in Blue):

① Wearable Device: Wear the device using lead wires or a vest (refer to the video in the app's How to Video). Lead wires are faster for resting ECGs, while vests can be used for both resting and Holter ECGs.

② View ECG: Link the device's serial number through the "StarCare Vets" app and view the six-lead ECG to check the wearing status. In "**Select Test**," select "**Resting ECG**"

and set or modify patient information. Use the list icon in the upper right corner to access saved information or manually enter it, then select "**Save.**"

③ Algorithm-Generated Report: After data acquisition, click "**Generate Report**" to view the ECG waveform and the diagnostic results. Veterinarians can edit the diagnostic statements by clicking the writing icon next to "Analysis Results." Confirm the report or select "**Reacquire**" if needed.

④ Resting ECG Report: After confirming, a standard PDF report is generated. For more accurate diagnostics, the report can be reviewed by StarCare Animals' clinical team [Note 1]. Select to send the PDF report or click ← to complete.

2. 6-Lead Holter (Steps in Orange)[Note 2]:

① Wearable Device: Follow the video instructions in the app's "**How-To Video**" to properly apply the sensor and device to your pet.

② View ECG: Link the device's serial number in the app to view the six-lead ECG [Note 3]. In "**Select Test,**" select "**Holter Monitoring**" and set or modify patient information. Use the list icon in the upper right corner to access saved information or manually enter new details. Choose a recording duration of 1, 2, or 3 days and select "**Save**."

③ Holter Collection Complete: Remove the device after the recording duration or at any desired time (≥30 min).

④ Data Transfer: Place the device in the charging dock and connect it to a PC via USB.

⑤ Algorithm-Generated Report: The software interprets the uploaded ECG waveform and generates a preliminary report.

⑥ Two-Tier Manual Review: Using the aECGMap Vet software, clinical personnel review and modify the algorithm's results.

⑦ Generate Holter ECG Report: Available in both electronic and printed formats.

Note 1
For service model details, please contact StarCare Animals' sales staff.

Note 2
During the process of collecting a long-term Holter ECG, you can press the "**Select Test**" button on the app and choose "**Resting ECG**" to simultaneously collect a 10-second resting ECG without affecting the recording of the Holter ECG. However, during the collection of the resting ECG, the pet must remain in a resting state.

Note 3
The app does not need to remain open during Holter recording but can be used for full-time monitoring when needed.

Chapter 4
Overview of ECG Analysis

4.1 ECG analysis algorithms

The automated analysis algorithms embedded in the aECGMap VET software may be unfamiliar to many veterinary practitioners. StarCare Animals' analysis algorithm, also known as the AI-assisted computer analysis algorithm (details in Section 4.4), includes both a resting ECG analysis algorithm and a Holter ECG analysis algorithm. Utilizing digital signal processing, pattern recognition, artificial intelligence (AI), and logic analysis, the algorithm incorporates diagnostic rules based on veterinary expertise and extensive clinical research to interpret the animal's ECG waveform. This aids practitioners in identifying potential heart health issues in pets.

Note

The analysis algorithm may not accurately interpret specific ECGs or produce errors in the presence of significant noise. Even in cases where veterinarians could easily judge the ECG waveform, the algorithm might give an incorrect result. As such, this algorithm should be used solely as a diagnostic aid, and users must understand its capabilities and limitations. Final diagnoses and treatment decisions should always be made by a qualified veterinarian.

4.2 Resting ECG Overview

A resting ECG is designed for the quick detection of persistent heart issues. This mode requires the pet to remain still for approximately 30 seconds. The 321V device will automatically select a stable 10-second ECG segment, which is transmitted to a server for analysis using the AI-assisted resting ECG algorithm. A diagnostic report is then generated for clinical reference.

The report includes:

1. Measurements: Individual intervals and ECG axes between the P-QRS-T complex.
2. Diagnostic statements: Analytical statements for comprehensive diagnosis, including arrhythmias, conduction blocks, atrioventricular abnormalities, ST-T changes, etc.

The entire waveform captured in the resting ECG can be presented on a single A4/Letter-sized page, allowing experienced cardiology veterinarians to bypass algorithmic conclusions, visually inspect the waveform, and provide a swift diagnosis.

Research indicates that it is more efficient and consistent for experienced ECG

veterinarians to manually correct the automated report rather than writing all diagnostic statements from scratch.

For those less familiar with pet ECGs, the algorithm's diagnostics provide significant auxiliary support, enhancing the efficiency of clinical staff in identifying potential anomalies.

> **Note**
> Due to potential algorithmic errors, veterinarians new to pet ECG may consider using a third-party review service for the automatically analyzed resting ECG reports. StarCare Animals' clinical team offers this service.

4.3 Holter ECG Overview

Pet Holter monitoring can record continuous ambulatory ECG data for 1 to 3 days. Unlike a resting ECG, a Holter ECG captures intermittent or paroxysmal cardiac events, including arrhythmias and transient myocardial ischemia.

Requirements: Since Holter monitoring aims to capture paroxysmal cardiovascular events, it must:

- Identify the location and type of each heartbeat.
- Analyze the ECGs before and after any abnormal beats to determine the type and duration of the irregular event.
- Provide a statistical analysis and summary based on the data collected.

Given the vast amount of data collected, manual analysis is nearly impossible. For instance, a cat with an average heart rate of 200 beats per minute will produce 12,000 beats in one hour and 288,000 beats in a single day.

Algorithm-Assisted Detection: Automated software is essential to analyze this data and provide initial interpretations. However, no algorithm is perfect. The large volume of data increases the risk of absolute error, while noise and complex waveforms during regular activities or exercise can further affect accuracy. This may result in the omission or misclassification of crucial ECG segments.

Manual Review: To ensure accuracy, all Holter ECG reports undergo a rigorous manual review by professionals. The final report includes:

- Statistical analysis of normal and abnormal heartbeats.
- Analysis of abnormal rhythm events and ST-segment changes.
- ECG strips highlighting key abnormal rhythms and ST-segment events.
- Veterinarian’s signature.

4.4 ECG Algorithm Processing and Report Generation

Although resting and Holter ECGs differ in clinical application and some operational aspects, their signal processing and analysis flows are largely similar. Below is a flowchart outlining the ECG algorithm processing steps:

① Demographics

Accurate information entry for pets is required, including:

- **Pet's Name, Species, Breed, Age, Gender, Weight, Patient Number, Department, Crate Number, and Medication History.**

- Owner's Name and Phone Number.
- Veterinarian's Name.

> **Note**
> Details like age, gender, species, breed, weight, and medication history significantly impact the analysis results.

② ECG Acquisition

Like human ECGs, pet ECGs record the electrical activity of the heart's atria and ventricles using electrode pads or clips attached to the skin.

- The ECG acquisition accuracy is 1.25 μV/LSB, with a sampling rate of 500 times/second.
- Multi-lead mode allows simultaneous acquisition of signals from all leads.

For resting ECGs, ensure the pet remains calm and still to minimize disturbances. The 321V device features Clear-10 technology, which evaluates the signal-to-noise ratio and selects the optimal 10-second data segment for analysis.

③ Pre-processing

Both resting and Holter ECGs undergo noise and interference reduction, including lead off, electrode potential drift, common-mode signal interference, and motion artifacts, to prevent misdiagnosis. Digital signal processing, such as filters, enhances ECG signal quality without compromising clinical diagnostics.

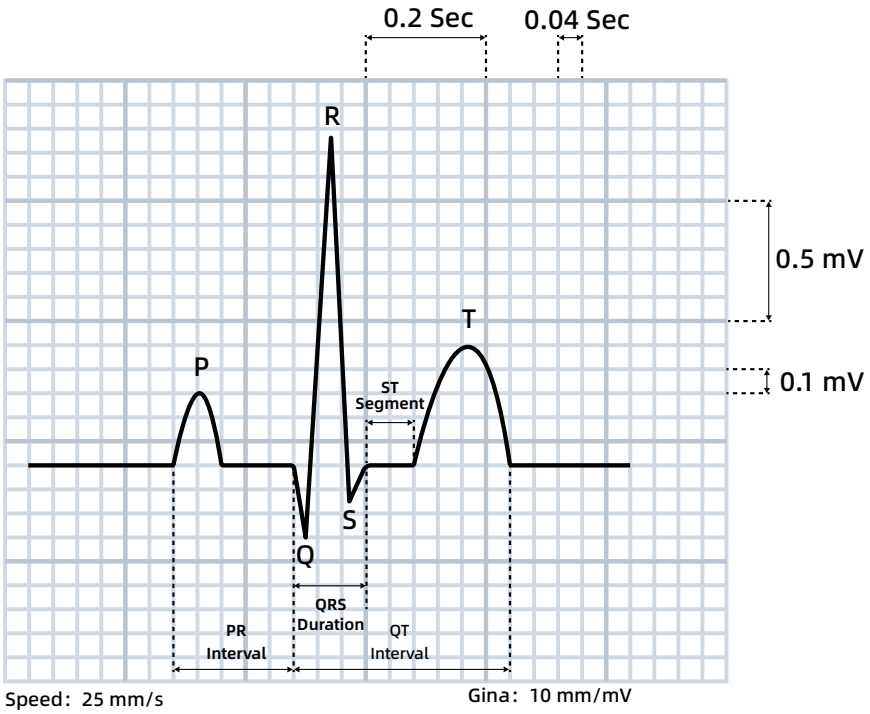
In this phase, the system also needs to identify heartbeats generated by an artificial pacemaker.

④ QRS Detection

Each normal heartbeat consists of a P wave, QRS complex, and T wave.

Electrocardiography: The ECG is recorded on a scaled grid, either on paper or in a digital format. On the ECG, time is represented horizontally. At the standard recording speed of 25 mm/s (millimeters per second), each 1-mm small grid corresponds to 0.04 seconds, each 5-mm large grid represents 0.2 seconds, and every set of 5 large grids (25 mm) equates to 1 second.

The vertical direction on the ECG indicates amplitude gain. The standard gain setting is 10 mm/mV (millimeters per millivolt), meaning each 1-mm small grid equals 0.1 mV, and each 5-mm large grid corresponds to 0.5 mV.



The algorithm detects the position of each QRS complex and calculates the heart rate.

Heart Rate Calculation

Heart rate (or ventricular rate) is determined by averaging all the RR intervals in an ECG over a given time period. For example, in a resting ECG, this is typically based on a 10-second waveform, while in a Holter monitor, it depends on the length of the ECG strip. The formula used is as follows:

$$\text{Heart Rate (bpm)} = \frac{60{,}000}{\text{Average RR Interval (ms)}}$$

Here, bpm refers to beats per minute, and "ms" represents milliseconds.

Instantaneous Heart Rate Estimation

The instantaneous heart rate can be roughly estimated based on the RR intervals. For example, if the RR interval spans one large grid (5 mm), the instantaneous heart rate is 300 bpm. For intervals covering 2 to 6 large grids, the corresponding heart rates are 150, 100, 75, 60, and 50 bpm, respectively (as shown in the figure below).

This method offers a quick way to estimate heart rate by simply observing the length of the RR interval, allowing for a rapid determination of the heart rate range.

⑤ Classification & Average Beat

In this step, the automated analysis algorithm uses pattern recognition to classify each QRS complex, identifying whether each heartbeat is normal or abnormal. Following this, computational methods such as averaging or median processing are applied to the normal beats for each lead to create a representative heart beat, commonly known as the "average beat."

Since ECG signals are often affected by various types of noise, it can be challenging to accurately identify key reference points, such as the start and end of each wave. Generating an average heartbeat waveform helps to "smooth out" these noises, resulting in a clearer representation with minimal distortion. This process facilitates the precise identification of the start and end points of the P, QRS, and T waves, as well as potential changes in amplitude.

⑥ Waveform Measurements

In this step, the algorithm first identifies the start and end points of the P, QRS, and T waves on the average beat. It then calculates key parameters, including the PR interval, QRS duration, QT interval, and ST-segment potential.

Within the average beat for each lead, a small segment of the signal before the QRS complex is used as the isoelectric line (zero potential point). The amplitudes of the P, Q, R,

S, and T waves, as well as any ST-segment elevation or depression, are measured relative to this baseline.

Since the QT interval can vary significantly with changes in the instantaneous RR interval, a corrected QT interval (QTc) is used clinically to obtain a value that remains consistent regardless of heart rate. StarCare Animals' algorithm applies Fridericia's formula for this correction:

$$QTc\ (ms) = \frac{QT\ (ms)}{\sqrt[3]{RR\ Interval\ (ms)}}$$

⑦ Rhythm Analysis

At this stage, the algorithm examines the P-QRS-T waves from both the average beat and the raw waveform to assess whether the ECG is in sinus rhythm or if there are any signs of arrhythmia, conduction blocks, and/or pacing rhythms.

⑧ Morphological Analysis

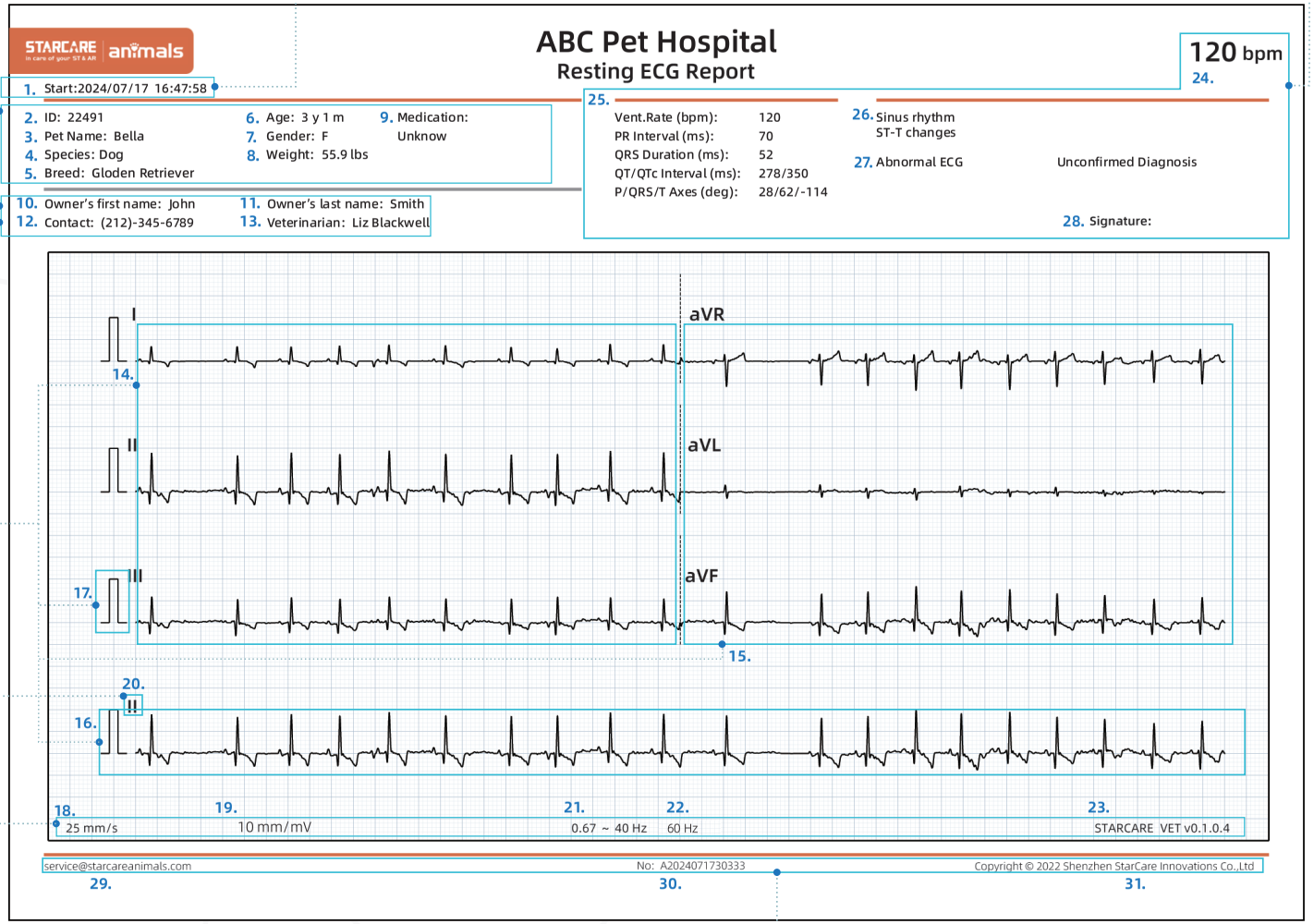
Using the automatically measured intervals and amplitudes of the P-QRS-T waves, StarCare Animals' algorithm employs an expert system and logical relationships to generate findings for Holter ECG and diagnostic statements for resting ECG. These statements, especially resting ECG, include rhythm analysis findings and morphological diagnoses, such as arrhythmias, conduction disorders, ST-segment/T wave abnormalities (indicative of ischemia), atrioventricular hypertrophy, etc.

⑨ Report Generation

The algorithm then produces a diagnostic report in a clinically standardized format, available both electronically and in print. The report contains patient and owner details, healthcare information, waveform tracings, technical information, analysis results or findings, and manufacturer information, serving as a direct reference for clinical practice.

4.5 Resting ECG Report Description

A resting ECG report is shown below, with descriptions of each section.



A.Acquisition information

1. Start date and time (yyyy/mm/dd hh:mm:ss)

B. Pet information

2. ID
3. Pet name
4. Species
5. Breed
6. Age
7. Gender:
   M (Male),
   F (Female),
   U (Unknown)
8. Weight
9. Medication history

C. Pet owner information

10. Surname
11. First name
12. Contact

D. Healthcare information

13. Veterinarian's name

E. ECG Printout

14. Lead I, II, and III waveforms for the first 5 seconds
15. Lead aVR, aVL, and aVF waveforms for the last 5 seconds
16. 10-sec rhythm lead
17. Calibration markers

F. Technical information

18. Paper speed
19. Gain
20. Lead
21. Bandwidth
22. AC power interference filter
23. Algorithm version

G. Analysis Result

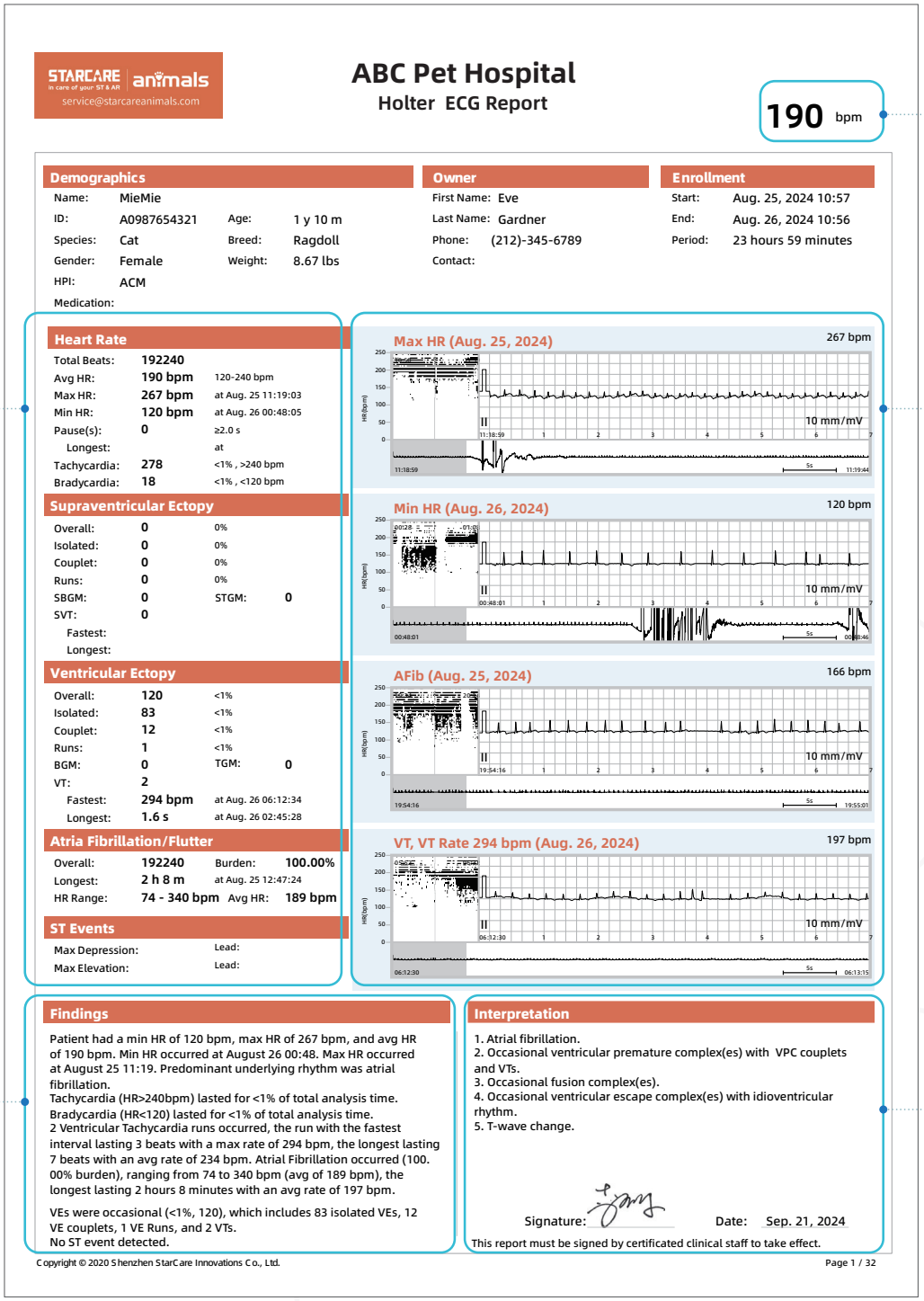
24. Ventricular rate, or heart rate
25. Measurements, including ventricular rate, PR interval, QRS duration, QT/QTc intervals, and P/QRS/T axes
26. Diagnostic statements
27. Summary statement
28. Signed by the veterinarian

H. Manufacturer Information

29. Customer support email address
30. Serial number of the report
31. Copyright and Manufacturer

4.6 Holter Report Description

A Holter ECG report is shown below, with descriptions of some section.



STARCARE animals
service@starcareanimals.com

ABC Pet Hospital
Holter ECG Report

190 bpm

Demographics

Name:	MieMie		
ID:	A0987654321	Age:	1 y 10 m
Species:	Cat	Breed:	Ragdoll
Gender:	Female	Weight:	8.67 lbs
HPI:	ACM		
Medication:			

Owner

First Name:	Eve
Last Name:	Gardner
Phone:	(212)-345-6789
Contact:	

Enrollment

Start:	Aug. 25, 2024 10:57
End:	Aug. 26, 2024 10:56
Period:	23 hours 59 minutes

Heart Rate

Total Beats:	192240	
Avg HR:	190 bpm	120-240 bpm
Max HR:	267 bpm	at Aug. 25 11:19:03
Min HR:	120 bpm	at Aug. 26 00:48:05
Pause(s):	0	≥2.0 s
Longest:		at
Tachycardia:	278	<1% , >240 bpm
Bradycardia:	18	<1% , <120 bpm

Supraventricular Ectopy

Overall:	0	0%	
Isolated:	0	0%	
Couplet:	0	0%	
Runs:	0	0%	
SBGM:	0	STGM:	0
SVT:	0		
Fastest:			
Longest:			

Ventricular Ectopy

Overall:	120	<1%	
Isolated:	83	<1%	
Couplet:	12	<1%	
Runs:	1	<1%	
BGM:	0	TGM:	0
VT:	2		
Fastest:	294 bpm	at Aug. 26 06:12:34	
Longest:	1.6 s	at Aug. 26 02:45:28	

Atria Fibrillation/Flutter

Overall:	192240	Burden:	100.00%
Longest:	2 h 8 m	at Aug. 25 12:47:24	
HR Range:	74 - 340 bpm	Avg HR:	189 bpm

ST Events

Max Depression:	Lead:
Max Elevation:	Lead:

Max HR (Aug. 25, 2024) 267 bpm

Min HR (Aug. 26, 2024) 120 bpm

AFib (Aug. 25, 2024) 166 bpm

VT, VT Rate 294 bpm (Aug. 26, 2024) 197 bpm

Findings

Patient had a min HR of 120 bpm, max HR of 267 bpm, and avg HR of 190 bpm. Min HR occurred at August 26 00:48. Max HR occurred at August 25 11:19. Predominant underlying rhythm was atrial fibrillation.
Tachycardia (HR>240bpm) lasted for <1% of total analysis time.
Bradycardia (HR<120) lasted for <1% of total analysis time.
2 Ventricular Tachycardia runs occurred, the run with the fastest interval lasting 3 beats with a max rate of 294 bpm, the longest lasting 7 beats with an avg rate of 234 bpm. Atrial Fibrillation occurred (100.00% burden), ranging from 74 to 340 bpm (avg of 189 bpm), the longest lasting 2 hours 8 minutes with an avg rate of 197 bpm.

VEs were occasional (<1%, 120), which includes 83 isolated VEs, 12 VE couplets, 1 VE Runs, and 2 VTs.
No ST event detected.

Interpretation

1. Atrial fibrillation.
2. Occasional ventricular premature complex(es) with VPC couplets and VTs.
3. Occasional fusion complex(es).
4. Occasional ventricular escape complex(es) with idioventricular rhythm.
5. T-wave change.

Signature: Date: Sep. 21, 2024

This report must be signed by certificated clinical staff to take effect.

Average Heart Rate

Statistical Summary

Key ECG Strips

Algorithm Findings

Manual Interpretation

Sample Cover Page from the Holter Report

Name: MieMie ID: A0987654321

Stats by Hour (Aug. 25, 2024)

Time	Beats	Heart Rate (bpm)			Supraventricular Ectopy					Ventricular Ectopy					Pause	Brady.
		Min	Avg	Max	Beats	Isolated	Couplet	Runs	SVT	Beats	Isolated	Couplet	Runs	VT		
10:57	586	187	199	227	0	0	0	0	0	0	0	0	0	0	0	0
11:00	12004	174	203	267	0	0	0	0	0	1	1	0	0	0	0	0
12:00	8899	136	193	250	0	0	0	0	0	4	4	0	0	0	0	0
13:00	7537	159	199	250	0	0	0	0	0	1	1	0	0	0	0	0
14:00	10154	131	195	241	0	0	0	0	0	1	1	0	0	0	0	0
15:00	7227	111	180	241	0	0	0	0	0	8	6	1	0	0	0	1
16:00	9476	122	193	234	0	0	0	0	0	0	0	0	0	0	0	0
17:00	10171	156	185	234	0	0	0	0	0	2	2	0	0	0	0	0
18:00	10431	156	203	234	0	0	0	0	0	4	4	0	0	0	0	0
19:00	10570	133	188	220	0	0	0	0	0	11	7	2	0	0	0	0
20:00	7341	133	191	250	0	0	0	0	0	4	4	0	0	0	0	0
21:00	8053	129	178	220	0	0	0	0	0	8	6	1	0	0	0	0
22:00	9418	174	192	241	0	0	0	0	0	8	8	0	0	0	0	0
23:00	6483	163	197	214	0	0	0	0	0	1	1	0	0	0	0	0
Total	118350	111	192	267	0	0	0	0	0	53	45	4	0	0	0	1

Stats by Hour (Aug. 26, 2024)

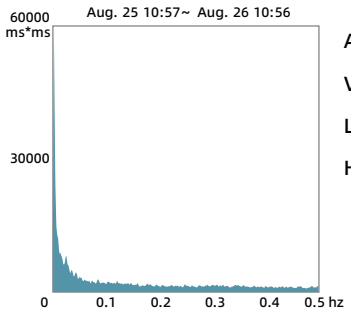
Time	Beats	Heart Rate (bpm)			Supraventricular Ectopy					Ventricular Ectopy					Pause	Brady.
		Min	Avg	Max	Beats	Isolated	Couplet	Runs	SVT	Beats	Isolated	Couplet	Runs	VT		
00:00	6919	119	180	220	0	0	0	0	0	5	3	1	0	0	0	1
01:00	5381	127	191	208	0	0	0	0	0	2	2	0	0	0	0	0
02:00	5688	141	189	220	0	0	0	0	0	10	0	0	1	1	0	0
03:00	10037	136	185	241	0	0	0	0	0	6	2	2	0	0	0	0
04:00	4039	147	178	220	0	0	0	0	0	1	1	0	0	0	0	0
05:00	7771	159	187	220	0	0	0	0	0	5	5	0	0	0	0	0
06:00	10291	138	188	234	0	0	0	0	0	13	6	2	0	1	0	0
07:00	5320	136	180	220	0	0	0	0	0	3	3	0	0	0	0	0
08:00	5802	147	179	227	0	0	0	0	0	4	4	0	0	0	0	0
09:00	6490	144	190	250	0	0	0	0	0	2	2	0	0	0	0	0
10:00	6152	150	183	241	0	0	0	0	0	16	10	3	0	0	0	0
Total	73890	119	185	250	0	0	0	0	0	67	38	8	1	2	0	1

Sample Page of Hourly Statistics from the Holter Report

Sample Page of Abnormal Rhythm Events from the Holter Report

Name: MieMie ID: A0987654321

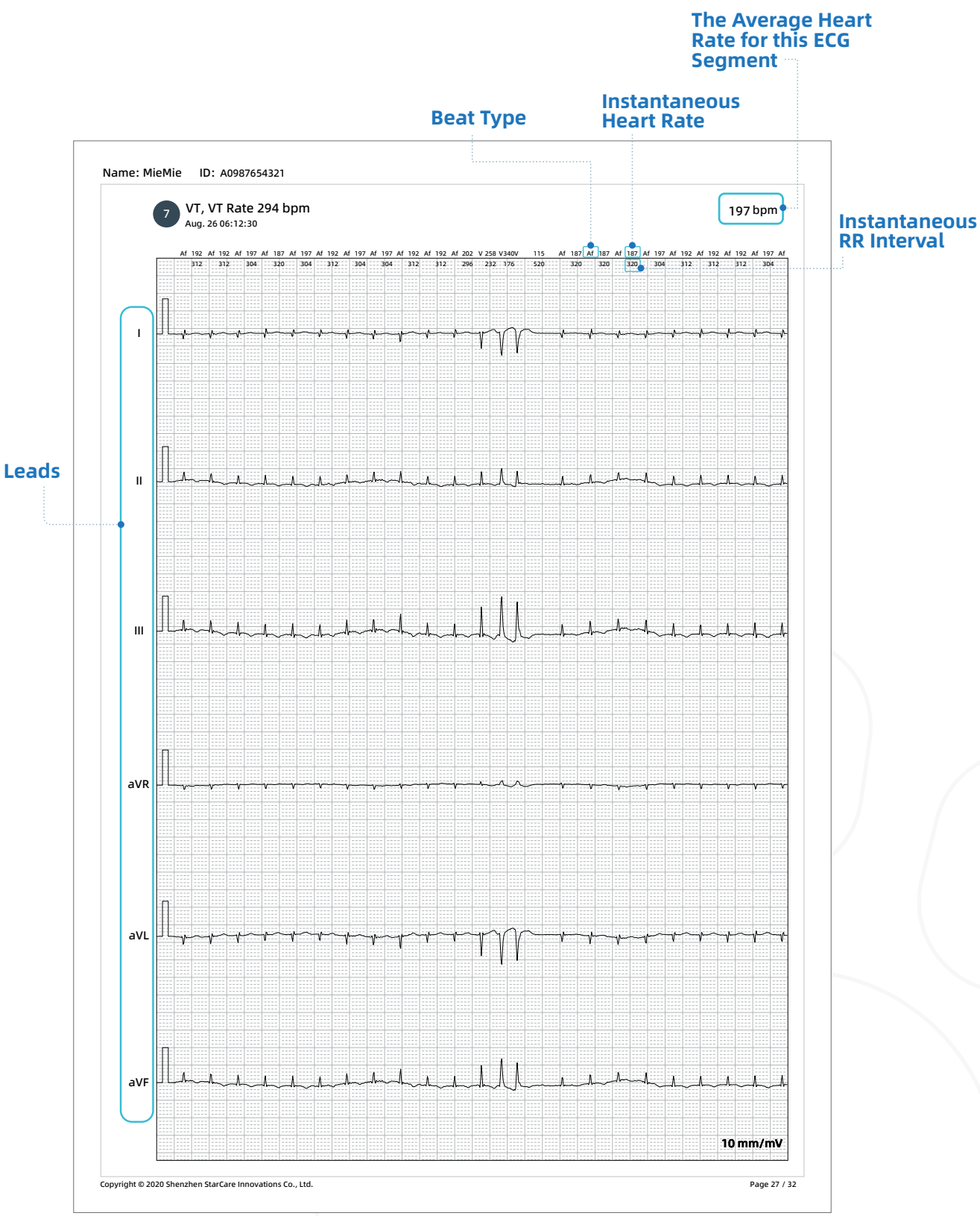
HRV Frequency Domain



Avg NN:	332 ms	LF nor	42.83 n.u.
VLF:	301.64 ms²	HF nor	56.90 n.u.
LF:	255.23 ms²	LF/HF:	0.75
HF:	339.06 ms²		

Type	Start Time	Duration	Avg NN	VLF (ms^2)	LF (ms^2)	HF (ms^2)	LF norm (n.u.)	HF norm (n.u.)	LF/HF
Global	Aug. 25 10:57	23:59:56	332	301.64	255.23	339.06	42.83	56.9	0.75
Day	Aug. 25 10:57	23:59:56	332	301.64	255.23	339.06	42.83	56.90	0.75
Hourly	Aug. 25 10:57	01:00:00	308	159.91	76.92	61.78	55.25	44.38	1.25
Hourly	Aug. 25 11:57	01:00:00	328	278.22	247.02	410.33	37.49	62.27	0.60
Hourly	Aug. 25 12:57	01:00:00	323	140.19	216.47	291.99	42.50	57.33	0.74
Hourly	Aug. 25 13:57	01:00:00	339	317.50	163.33	197.57	45.09	54.55	0.83
Hourly	Aug. 25 14:57	01:00:00	380	938.75	955.11	965.20	49.64	50.17	0.99
Hourly	Aug. 25 15:57	01:00:00	344	486.99	277.01	567.52	32.75	67.10	0.49
Hourly	Aug. 25 16:57	01:00:00	333	74.55	35.14	55.62	38.64	61.16	0.63
Hourly	Aug. 25 17:57	01:00:00	317	265.62	273.29	266.69	50.54	49.32	1.02
Hourly	Aug. 25 18:57	01:00:00	327	513.86	212.70	265.02	44.35	55.26	0.80
Hourly	Aug. 25 19:57	01:00:00	341	863.36	593.71	685.22	46.32	53.46	0.87
Hourly	Aug. 25 20:57	01:00:00	347	263.41	312.93	278.44	52.70	46.90	1.12
Hourly	Aug. 25 21:57	01:00:00	317	24.28	39.57	52.72	42.69	56.87	0.75
Hourly	Aug. 25 22:57	01:00:00	308	42.25	55.35	134.55	29.03	70.56	0.41
Hourly	Aug. 25 23:57	01:00:00	341	657.75	380.52	473.75	44.47	55.37	0.80
Hourly	Aug. 26 00:57	01:00:00	315	52.65	87.78	167.85	34.25	65.49	0.52
Hourly	Aug. 26 01:57	01:00:00	323	156.94	104.89	167.77	38.41	61.45	0.63
Hourly	Aug. 26 02:57	01:00:00	326	227.22	206.69	281.55	42.24	57.54	0.73
Hourly	Aug. 26 03:57	01:00:00	351	324.74	224.53	441.99	33.58	66.09	0.51
Hourly	Aug. 26 04:57	01:00:00	327	121.66	127.26	189.64	40.07	59.70	0.67
Hourly	Aug. 26 05:57	01:00:00	326	189.39	171.58	241.32	41.44	58.29	0.71
Hourly	Aug. 26 06:57	01:00:00	347	269.75	322.87	454.71	41.39	58.29	0.71
Hourly	Aug. 26 07:57	01:00:00	359	281.56	514.79	686.81	42.76	57.04	0.75
Hourly	Aug. 26 08:57	01:00:00	353	556.47	725.92	981.68	42.34	57.26	0.74
Hourly	Aug. 26 09:57	00:59:56	354	428.12	349.69	509.13	40.58	59.09	0.69

Sample Page of Heart Rate Variability (HRV) from the Holter Report



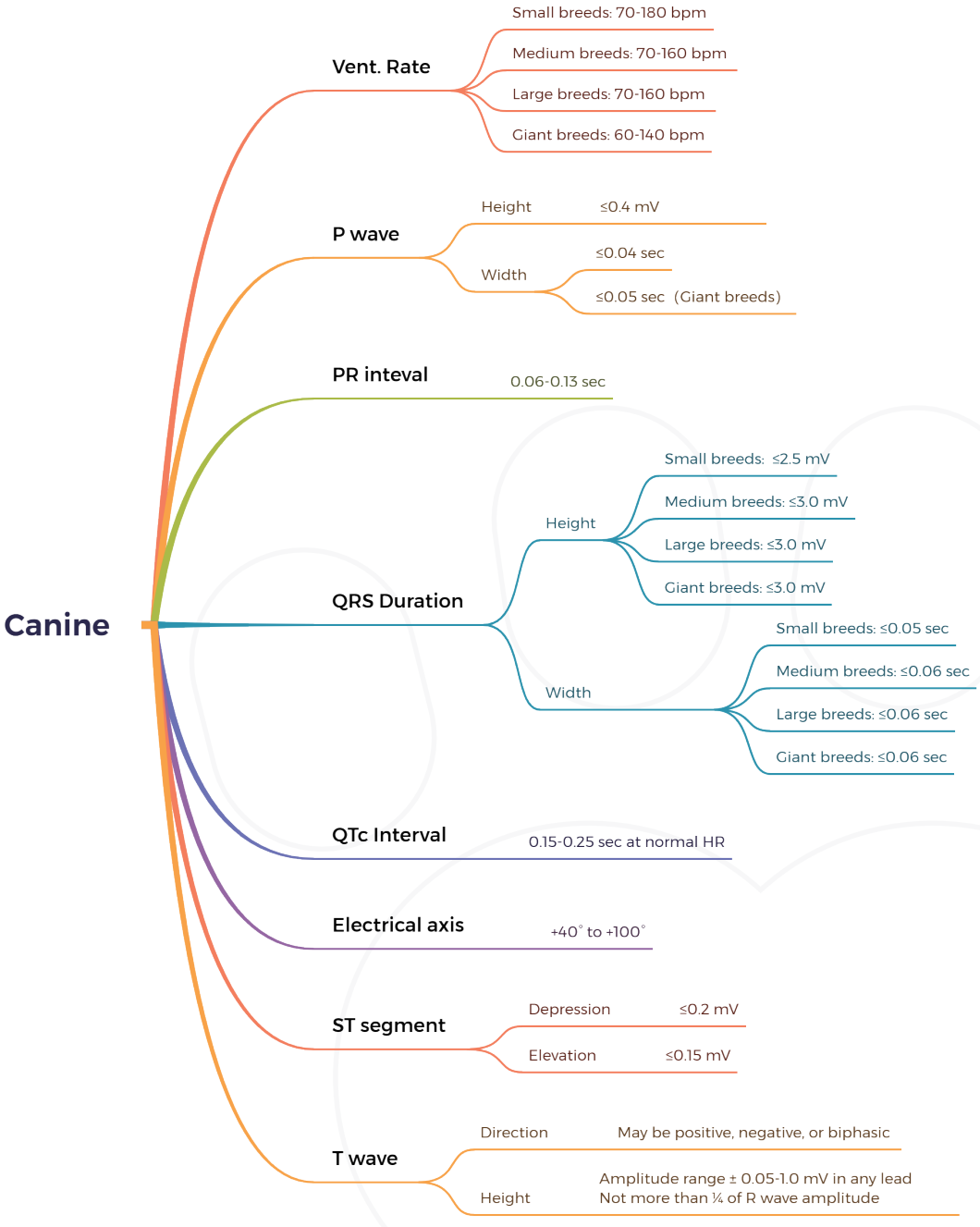
Sample Page of ECG Strips from the Holter Report

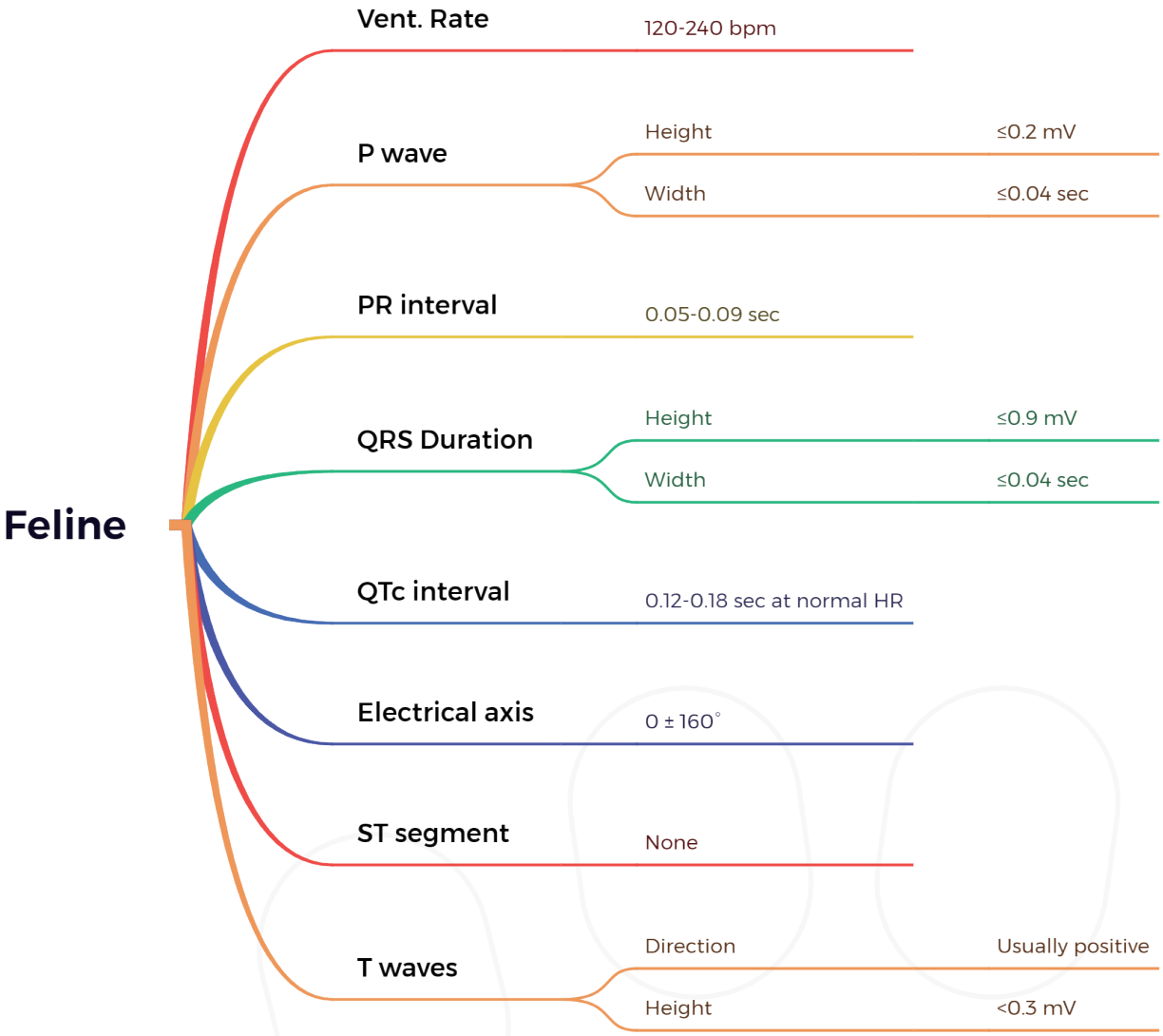
Chapter 5
Normal Measured Values

StarCare Animals's algorithm uses the following values to determine the normal ECG ranges in canines and felines [Note 1][Note 2]:

The size of the dog is categorized by weight as follows:

Small breeds: 2.2 - 23 lbs. (1-10 kg)
Medium breeds: 24 - 58 lbs. (11-26 kg)
Large breeds: 59 - 99 lbs. (27-45 kg)
Giant breeds: 100+ lbs. (45+ kg)





Note 1
Modified from Table 3.1, F. Smith, Manual of Canine and Feline Cardiology, fifth edition, 2016.

Note 2
Unless otherwise specified, measurements are for lead II.

Chapter 6
Algorithm Statements and ECG Strips

6.1 Atrial Rhythm

(1) Sinus Rhythm

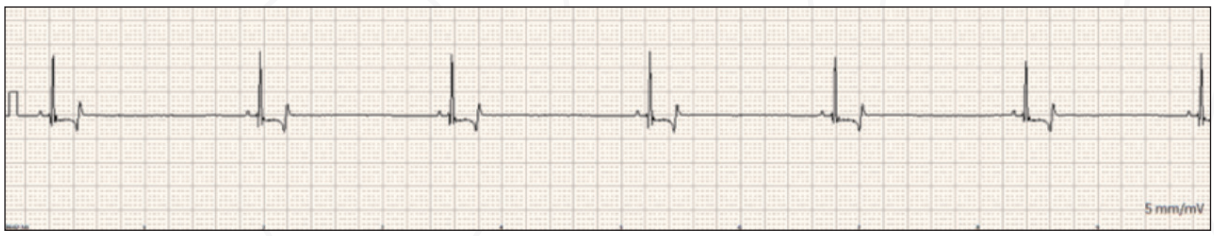
Cat, female, 1 year old, 4.4 lbs:

· Ventricular rate: 115 beats/min
· Sequentially sinus P waves occur with a rate of 115 times/min
· Normal QRS complex interval
· Normal ventricular conduction.

(2) Sinus Bradycardia

Dog, female, 4 years old:

· Ventricular rate: 39 beats/min
· Sequential sinus P waves with a rate of 39 times/min
· Normal PR interval
· Normal QRS complex interval.



(3) Sinus Tachycardia

Dog, female, 7 years old:

· Ventricular rate: 220 beats/min
· Sinus P waves with a rate of 220 times/min
· Fixed PR interval
· Normal QRS complex interval.

(4) Sinus Pause

Dog, female, 4 years old:

· Sinus rhythm with a PP interval exceeding 2 seconds after a regular interval

· No multiple relationship between long and short PP intervals.

(5) Supraventricular Tachycardia

Dog, Golden Retriever, female, 7 years old:

· Ventricular rate: 205 beats/min

· Early occurrence of the 8th to 25th consecutive beats; atrial P' wave different from sinus P wave before the QRS complex

· QRS duration: 0.05 seconds.

(6) Atrial Fibrillation

Cat, female, 3 years old:

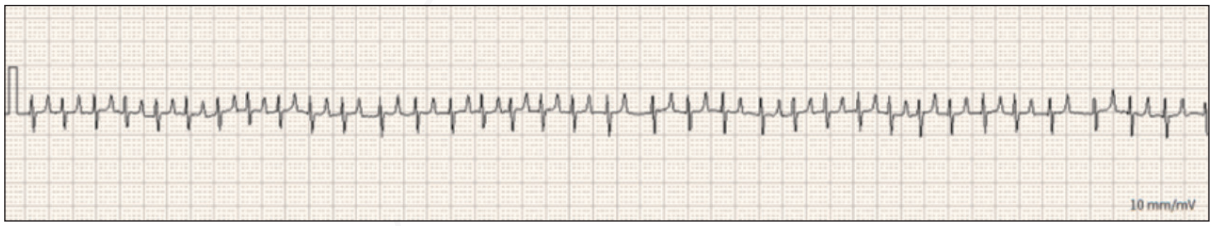
· Ventricular rate: 208 beats/min

· Absence of P waves

· Unequal RR interval

· QRS complex duration: 0.045 seconds

· Normal intraventricular conduction.



6.2 Ventricular Arrhythmias

(1) Premature Ventricular Contractions

Dog, male, 15 years old, 19.2 lbs:

· Ventricular rate: 107 beats/min

· 5th, 13th, and 18th beats are narrow premature QRS complexes with flattened P waves, which is sinus rhythm with occasional premature atrial contractions

· 10th beat: wide QRS complex, indicating interpolated premature ventricular contractions.

(2) Paired Ventricular Premature Contractions

Dog, female, 7 years old:

· Ventricular rate: 192 beats/min

· Sinus tachycardia

· 14th and 15th beats: paired premature ventricular contractions

· 17th beat: single premature ventricular contraction.

(3) Ventricular Bigeminy

Cat, male, 6 years old:

· Ventricular rate: 144 beats/min

· Alternating sinus beats and premature ventricular contractions form a bigeminy rhythm.

(4) Ventricular Trigeminy

Cat, male, 6 years old:

· Ventricular rate: 144 beats/min

· Premature ventricular contractions alternate with sinus beats in an NNV-NNV-NNV pattern, creating a trigeminy rhythm.

(5) Non-sustained Ventricular Tachycardia

Cat, male, 6 years old:

· Ventricular rate: 144 beats/min

· 7th beat: single premature ventricular contraction

· Beats 13, 14, and 15: short-run ventricular tachycardia with a rate of 300 beats/min.

(6) Idioventricular Rhythm with 3rd-Degree Atrioventricular Block

Dog, female, 13 years old, weighing 16.5 lbs:

· Ventricular rate: 33 beats/min

· Sinus P waves not associated with QRS complexes, indicating 3rd-degree atrioventricular block

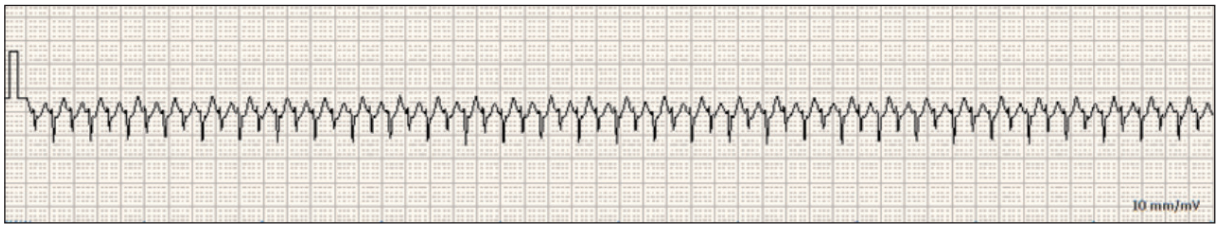
· Independent ventricular impulses with QRS duration of 0.11 seconds.

(7) Wide QRS Tachycardia

Cat, female, 1 year old:

· Ventricular rate: 394 beats/min

· QRS complex is rS type with a duration of 0.06 seconds.



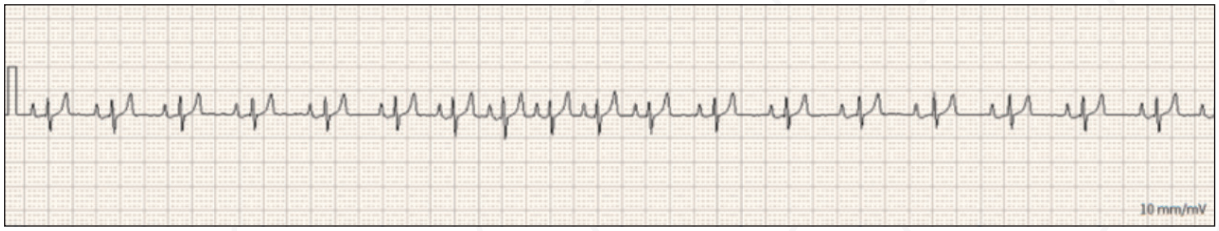
6.3 Conduction Defects

(1) 1st-Degree Atrioventricular Block

Dog, male, 14 years old, 18.7 lbs:

· Ventricular rate: 113 beats/min

· PR interval: 0.15 seconds (normal range: 0.06 to 0.13 seconds).



(2) 2nd-Degree Atrioventricular Block

Dog, female, 4 years old:

· Ventricular rate: 60 beats/min

· Regular sinus rhythm with intermittent nonconductive P waves

· No premature atrial contractions.

(3) 3rd-Degree Atrioventricular Block

Dog, female, 13 years old, weighing 16.5 lbs:

· Ventricular rate: 37 beats/min

· No fixed relationship between sinus P waves and QRS complexes

· Junctional escape rhythm present.

(4) High-Grade Atrioventricular Block

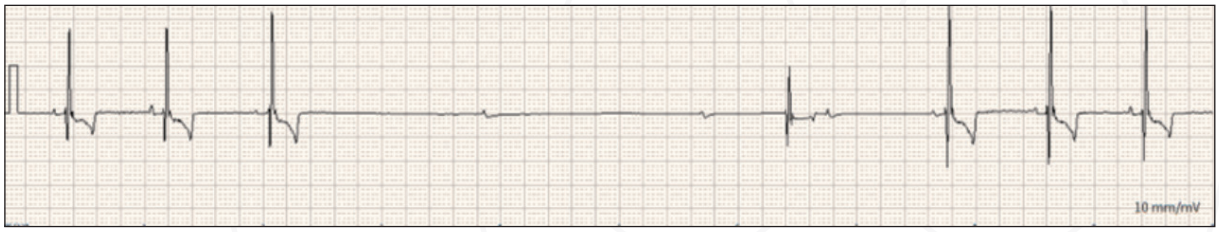
Dog, female, 10 years old, 9.9 lbs, with a history of syncope:

· Ventricular rate: 69 beats/min

· Some beats show an rSR' pattern, suggesting a right bundle branch block

· High-grade atrioventricular block present, as seen by the prolonged pause after the 3rd beat, with 2 sinus P waves and no subsequent QRS complex

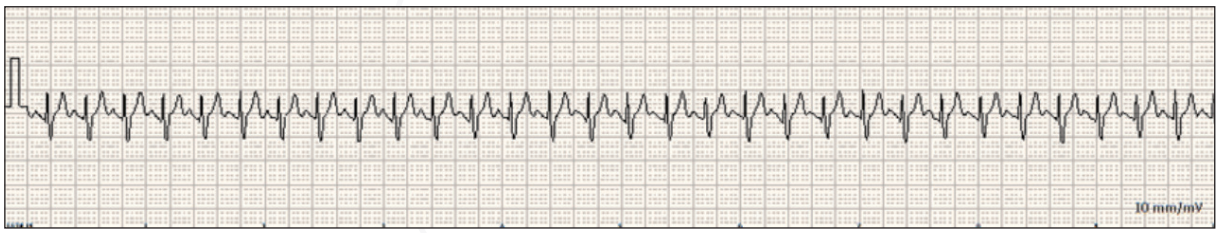
· The 4th beat is slightly narrower than the others and is identified as a borderline escape beat.



(5) Right Bundle Branch Block

Dog, male, 8 years old, 88.2 lbs:

· RS type in lead II, QRS duration: 0.09 seconds; complete right bundle branch block.



(6) Left Bundle Branch Block

Cat, male, 8 years old:

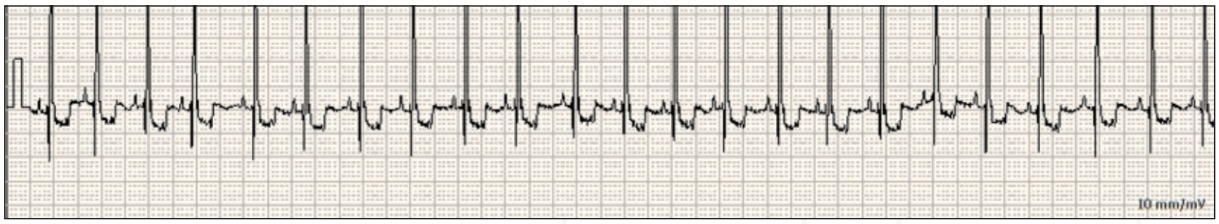
· R-type QRS complex in lead II with a duration of 0.08 seconds; complete left bundle branch block.

6.4 ST-Segment or T-Wave Abnormalities

(1) ST-Segment Depression

Dog, male, 7 months old:

· ST segment horizontally depressed by 0.35 mV.



(2) ST-Segment Elevation

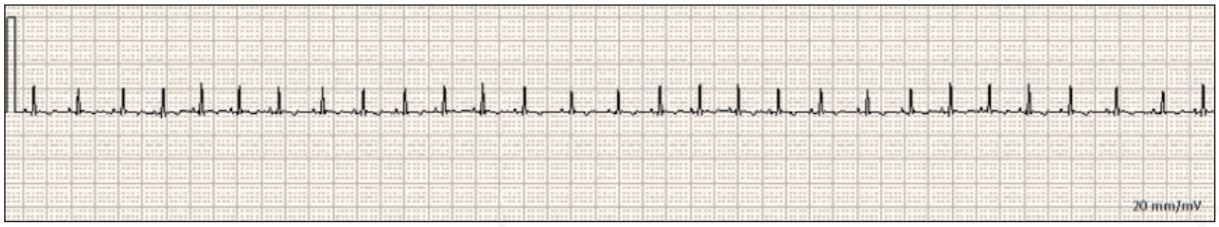
Cat, male, 7 years old, 7.7 lbs:

· ST segment elevated by 0.30 mV in an arched shape.

(2) T Wave Changes

Cat, male, 5 years old:

· Inverted T wave.



(4) ST-Segment Change

Dog, male, 4 years old, 15.4 lbs:

· ST segment arched, convex by 0.20 mV.

(5) ST-T Changes

Dog, male, 15 years old, 19.2 lbs:

· Ventricular rate: 153 beats/min

· ST segment depressed by 0.40 mV

· Inverted T wave.

(6) High T waves

Cat, 1 year old, male, 11.9 lbs:

· T wave amplitude: 0.4 mV.

6.5 Atrial Enlargement

(1) Left Atrial Abnormality

Dog, male, 5 years old:

· Ventricular rate: 111 beats/min

· P wave duration: 0.10 seconds; indicates left atrial enlargement.

(2) Right Atrial Abnormality

Dog, male, 15 years old:

· Ventricular rate: 141 beats/min

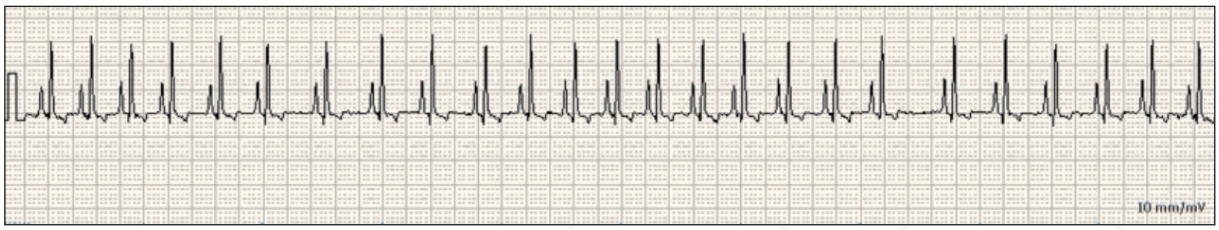
· P wave amplitude: 0.5 mV, lasting 0.03 seconds; suggests right atrial enlargement.

(3) Biatrial Enlargement

Dog, female, 13 years old:

· Ventricular rate: 156 beats/min

· P wave amplitude: 0.65 mV, lasting 0.06 seconds; shows left and right atrial enlargement.



6.6 Ventricular Hypertrophy

(1) Left Ventricular Hypertrophy

Dog, male, 15 years old, 19.2 lbs:

· Ventricular rate: 122 beats/min

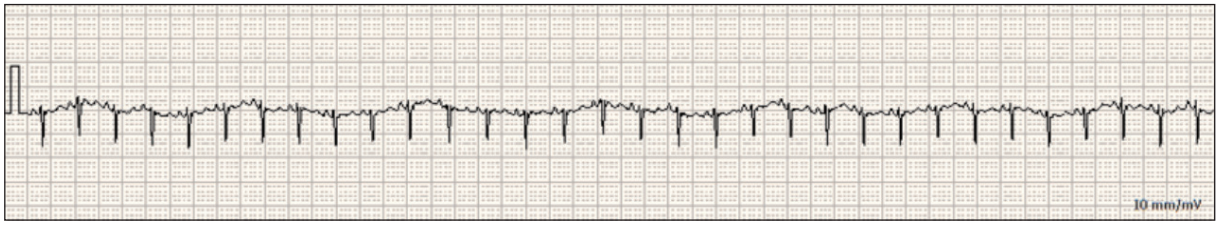
· R-wave amplitude in lead II: 3.5 mV, indicating left ventricular enlargement.

(2) Right Ventricular Hypertrophy

Cat, female, 3 years old, 13.7 lbs:

· Ventricular rate: 192 beats/min

· S wave in lead II suggests right ventricular enlargement.



6.7 Summary Codes

This section is particularly relevant for resting ECG reports. After providing a series of diagnostic statements, the algorithm concludes with one of the following:

1.Normal ECG

2.Normal ECG except heart rate

3.Normal ECG except for rhythm

4.Borderline or normal variant ECG

5.Abnormal ECG

6.Technical errors

Note

The results of the ECG algorithm analysis must be reviewed by a qualified veterinarian and should not be used as a sole basis for prescribing treatment.

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