

## Chapter 2

### **The normal ovine electrocardiogram: A 12-leaded approach**

As a non-invasive laboratory procedure for evaluating the heart, electrocardiography is without equal. The technique is simple and reproducible and the record lends itself to repetitive and serial studies.

Sheep are popular among electrophysiologists for the study of various primary and secondary electrophysiological perturbations <sup>1, 2, 3, 4, 5</sup>. However, a search of the Medline and Premedline databases, between 1966 and 2002, did not reveal any literature describing a practical method of obtaining a 12-lead electrocardiogram (ECG) with a six channel electrocardiograph in sheep. Using the standard limb and unipolar leads with a one channel electrocardiograph Pretorius *et al* could not reproducibly demonstrate a constant electrocardiographic tracing <sup>6</sup>. However, by moving Einthoven's triangle from the frontal to the sagittal plane, by the moving the standard limb and unipolar electrodes, Schultz *et al* were able to demonstrate a constant electrocardiographic tracing <sup>7</sup>. This study, however was done with a one channel electrocardiograph and constancy was only demonstrated in the standard limb and unipolar electrodes.

A practical and reliable method for obtaining a 12-lead electrocardiographic tracing in sheep is essential for two reasons. First, an ovine model can be utilized in various cardiovascular experimental protocols and second, the hearts of sheep are affected in several plant poisoning syndromes in South Africa with obvious economic importance to farmers<sup>6,7</sup> and if it can be shown that a reliable electrocardiographic tracing can be utilized to detect such poisoning syndromes it will have importance to such farmers.

In order to be able to utilize an ovine model in proving or rejecting the hypothesis it is therefore essential that a practical, reliable and reproducible method of performing a 12-lead ECG with a six channel electrocardiograph is obtained. The purpose of this study therefore was to develop such a method of obtaining electrocardiographic tracings with a six channel electrocardiograph.

### **Materials and Methods**

This study was performed with the approval of the ethics committee of the University of Pretoria's Biomedical Research Centre.

15 clinically normal Dorper wethers, all between the ages of 10 and 12 months, and weighing between 35 and 40 kg were used in this study. They were fed on lucerne hay *ad libitum*, received 300g/day of pelleted concentrate (10 MJ ME/kg DM with 14% crude protein) and had free access to water at all times.

The sheep were sedated and placed in the right lateral decubitus position (Figure 2.2). There were two groups: In the first group (n=8), the sheep were sedated with ketamine hydrochloride (Brevinaze) at a dose of 100 mg IM once only and in the second group (n=7) all the sheep were sedated with midazolam (Dormicum) at a dose of 30 mg IM once only. After an interval of approximately 10 minutes in every case there were no spontaneous movements and the sheep were placed in the right lateral decubitus position. This method of sedating the animal made it possible for one person to perform electrocardiography without any help and it also eliminated all limb movements which will cause disturbances on the electrocardiographic tracing. The reason for having two groups regarding anaesthetic agent was to evaluate the possibility that the choice of anaesthetic agent will have a major modifying effect on the ECG tracing.

In an attempt to reduce the ECG variations encountered in normal animals, Einthoven's triangle was moved from the frontal to the sagittal plane as previously described by Schultz *et al*<sup>7</sup> by moving the standard and unipolar limb electrodes as follow:

- (a) The right arm lead was moved from the right fore limb to the head between the ears (aVR).
- (b) The left arm lead was moved from the left fore limb to the dorsum of the sacrum (aVL).

- (c) The left leg lead was moved from the left hind limb to the sternal angle (aVF).
- (d) the earth electrode was placed on the right hind leg, just above the hock.

The six precordial electrodes were placed as follow:

- (a) V1: Placed 7 cm to the right of the sternal angle.
- (b) V2: Placed 7 cm to the left of the sternal angle.
- (c) V3: Placed 4.5 cm below and 1 cm to the left of V2.
- (d) V4: Placed 4.5 cm below and 1 cm to the left of V3.
- (e) V5: Placed 4.5 cm below and 1 cm to the left of V4.
- (f) V6: Placed 4.5 cm below and 1 cm to the left of V5.

This specific positioning of the six chest leads was arbitrary as we wanted to demonstrate reproducibility and constancy in the morphology of the electrocardiographic tracings between all 15 sheep and in the right lateral decubitus position this specific positioning of the leads is easily obtained.

The electrodes used in all 12 leads were Meditrace 200, disposable ECG, conductive, adhesive electrodes. The skin areas where ECG electrodes were placed were shaven and the electrodes secured to the skin with Super Glue (Bostik). A 12-lead electrocardiogram was then performed in every case with a

Schiller AT-2 plus 6-channel electrocardiograph. The paper speed was set at 25 mm/s and calibrated at 1 mm height = 0.1 mV.

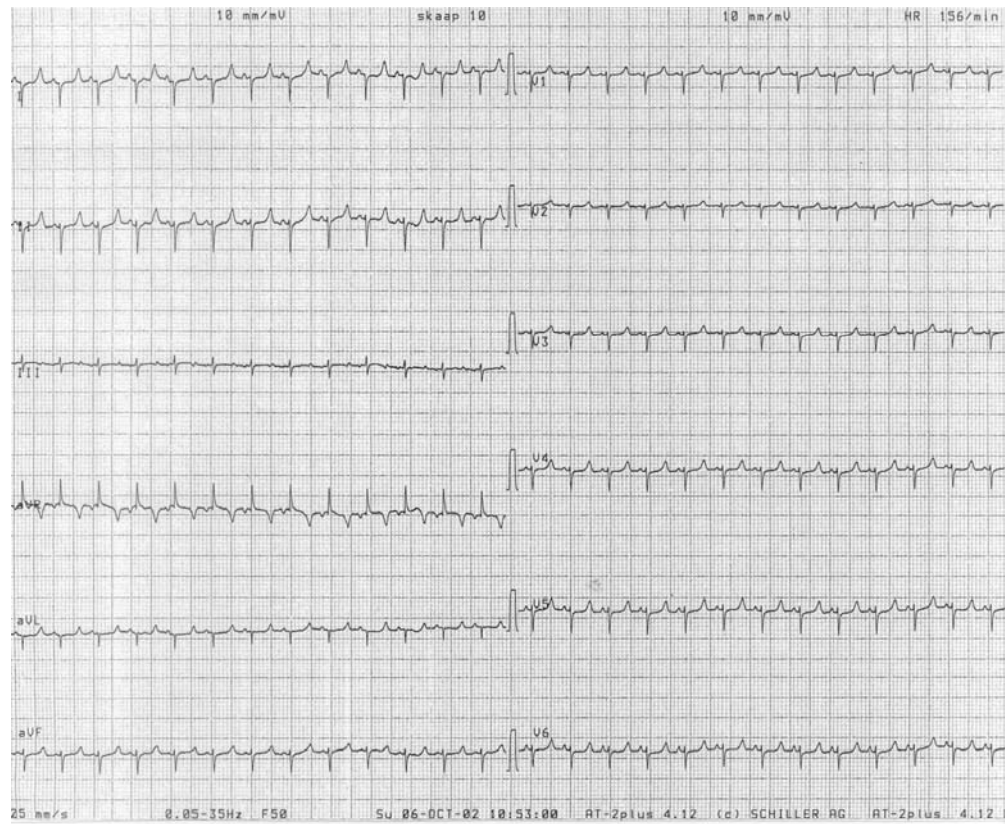
### **Results**

The electrocardiographic tracings of all 15 sheep demonstrated the same constant configuration of the precordial leads (V1 – V6).

During normal sinus rhythm an rS pattern was constantly and repetitively shown in all 6 the precordial leads. Importantly, the polarity of the T wave was also constantly positive in all 6 of the precordial leads. Table I describes the characteristics of the ECG components.

**Table 1** Characteristics of the normal ovine ECG

	<b>Ketamine (n=8)</b>			<b>Midazolam (n=7)</b>		
	<b>Mean</b>	<b>Min</b>	<b>Max</b>	<b>Mean</b>	<b>Min</b>	<b>Max</b>
Heart rate (beats/min)	171.00	163.00	181.00	151.00	130.00	185.00
P-wave duration (msec)	64.00	50.00	74.00	52.00	47.00	56.00
P-wave amplitude (mV)	0.09	0.04	0.16	0.07	0.06	0.09
PR interval (msec)	80.00	74.00	90.00	85.00	70.00	96.00
QRS duration (msec)	44.00	42.00	48.00	51.00	38.00	60.00
QT interval (msec)	220.00	208.00	228.00	258.00	212.00	288.00
QRS axis (°)	-151.00	-138.00	-165.00	-147.00	-93.00	-168.00
T-wave axis (°)	43.00	22.00	58.00	40.00	23.00	59.00
Sokolow index (SV1 + RV5 in mV)	0.42	0.29	0.61	0.54	0.31	0.77



**Figure 2.1.** The normal ovine 12-lead electrocardiogram.

## **Discussion**

Schultz *et al*<sup>7</sup> demonstrated a technique by which reproducible 6-lead electrocardiograms (utilizing the 3 standard limb-: aVR, aVL, aVF and unipolar leads: I, II, III) can be recorded in normal sheep. In this study their method of placing the limb and unipolar leads was used, but a new method to obtain a reproducible 12-lead electrocardiogram, including the six precordial electrodes with a 6-channel electrocardiograph was developed. Of interest is the positive polarity of the tracing obtained with lead aVR. This was also seen in the study by Schultz *et al*<sup>7</sup> and furthermore the rS pattern of the six precordial leads was consistent. Note that this is most probably due to the fact that lead V6 is not facing the left ventricle. However, the purpose of this study was to find a practical way of placing the six precordial leads that will lead to a consistent tracing among different sheep and in sheep in the right lateral decubitus position this is the most lateral placement possible, without the sheep overlying the electrocardiographic leads.

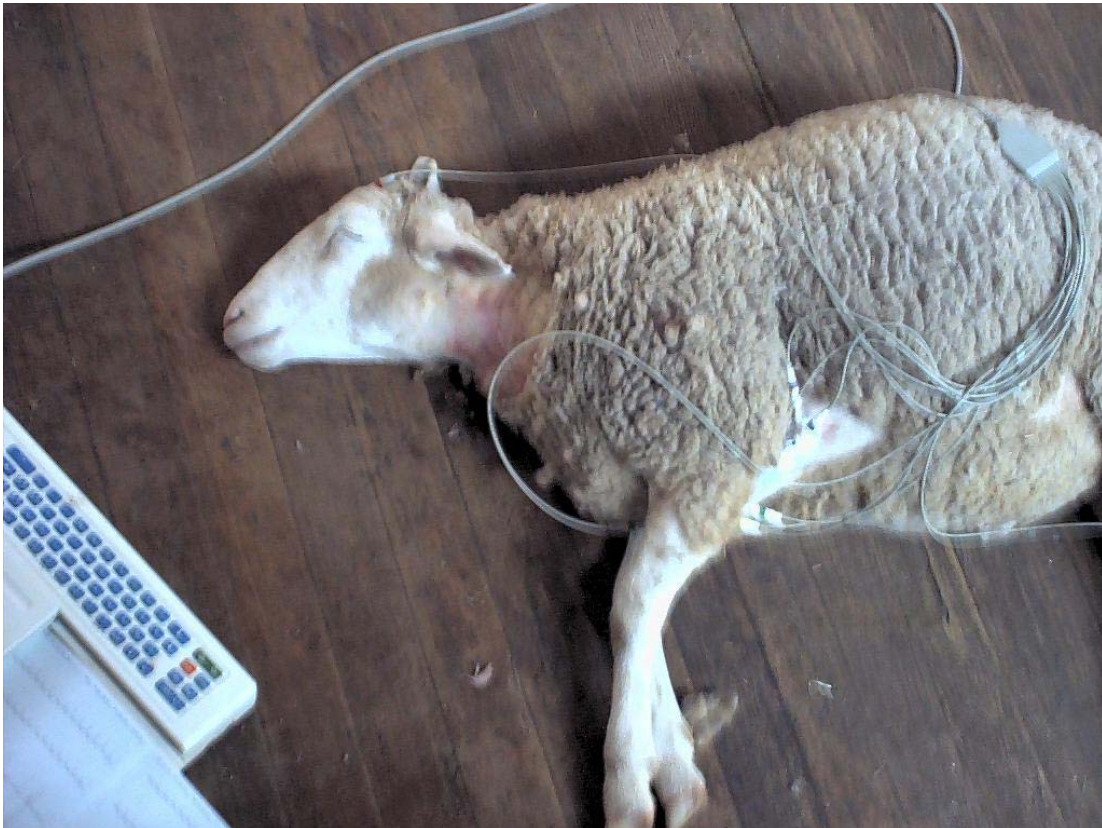
The main purpose of this experiment was twofold. Firstly, to determine whether our positioning of the 6 precordial electrodes in a 12-lead ovine electrocardiogram yields reproducible tracing between different sheep and secondly, to note the polarity of the T waves in the six chest leads, as later on we will be looking at post-extrasystolic T wave changes.

There were 2 groups of sheep with regard to choice of anaesthetic agent—the first group were sedated with ketamine and the second with midazolam. This



was done in order to determine whether there would be any possible differences in the 6 precordial leads with regard to the QRS pattern and/or QRS-, P-, and T wave polarity. The 6 precordial tracings were identical in all 15 sheep: rS pattern of the QRS complex with positive P and T waves.

This method of obtaining a 12-lead, 6-channel ECG in sheep is proposed as valid, easy and reproducible. Furthermore, the method of sedation makes it possible for one person to perform electrocardiography in sheep, without any concern that this will influence the tracing.



**Figure 2.2.** Dorper wether in right lateral decubitus position

## References

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