Chapter 3

The morphology of premature ventricular complexes in the dorper sheep heart

A premature ventricular complex (PVC) is the expression of an impulse that arises prematurely in an ectopic ventricular focus and can originate in the specialized conduction tissue distal to the bifurcation of His or in the ventricular myocardium itself [1, 2]. On the 12-lead, surface electrocardiogram PVC's are recognized by the premature occurrence of a QRS complex that is abnormal in shape and with a duration that exceeds that of the dominant QRS complex. The T wave is opposite in direction to the major deflection of the QRS complex [2]. However, narrow PVC's can occur and have been explained as originating at a point equidistant from each ventricle in the ventricular septum or by arising high in the fascicular system [3]. Currently three mechanisms of PVC generation are recognized: enhanced automaticity, triggered activity and reentry [4].

In the human heart it has been shown that certain characteristics of a PVC can reflect either the presence or absence of myocardial disease [1, 5, 6]. Normal PVC's (those not complicated by myocardial disease) has the following characteristics [1, 5]: 1) The QRS amplitude is large and exceeds 20 mm or higher. 2) The QRS complex does not exceed 120 msec in duration. 3) The QRS deflection has a smooth contour with no notching. 4) The ST segment and T wave are opposite in direction to the QRS deflection. 5) The ST segment does not display any isoelectric period. 6) The ST segment blends imperceptibly with the proximal limb of the T wave so that the two cannot be separated. 7) The T wave has asymmetrical limbs.

It has been shown that primary myocardial disease can alter these features of "uncomplicated" PVC's and any one or more of the following changes can occur [1, 5], thus yielding a "complicated" PVC:

1) The QRS complex is diminished in amplitude.
2) The QRS complex widens and exceeds 120 msec.
3) There is marked notching and irregularity of the QRS complex.
4) The ST segment displays an isoelectric period.
5) The T waves tend to be sharply pointed and symmetrical.
6) The T wave has the same direction as that of the QRS complex.

For the purpose of this study it is necessary to document the morphological features of PVC's in the normal Dorper sheep heart as this has not been described in the literature before. This is important for two reasons. First, it is essential that PVC's can be accurately identified on the 12-lead surface electrocardiogram, as they will be used later on to induce cardiac memory T waves, and secondly we want to evaluate the possibility that these morphological features may change if individual sheep are exposed to prolonged periods of PVC`s.

Materials and Methods

The first 5 sheep that were used in chapter 2 were taken out of this study: they were slaughtered and their hearts were subjected to histological examination so that they can serve as normal histological controls (see chapter 4). The remaining 10 sheep that were used in chapter 2 were used in this study. These 10 sheep were designated sheep 1 to 10.

These 10 Dorper wethers were sedated and electrocardiography was performed as described in chapter 2. Right ventricular PVC's were induced in all 10 sheep. The guidewire of an Arrow central venous pressure catheter set (spring-wire guide with diameter 0.81 mm and length 60 cm, straight soft tip on one end and J tip on the other end.) were advanced into the right ventricle via the left internal jugular vein by the Seldinger technique. The guidewire was introduced with the soft tip in front with the sheep lying sedated in the right lateral decubitus position. The position of the guidewire was confirmed with an X-ray and PVC's were then induced by mechanical movement of the guidewire. This method of inducing PVC's was chosen because of the observation that so-called "tip extrasystoles" are often seen during the implantation of ventricular pacemakers in humans [7].

These 10 Dorper wethers were then exposed for variable periods to PVC's (see table 3.1).

Table 3.1. PVC load

Sheep number	Days subjected to PVC's	Number of PVC's counted
1	60 minutes	55
2	15 days	221
3	1 day	80
4	36 days	575
5	9 days	150
6	28 days	371
7	16 days	1887
8	13 days	210
9	53 days	902
10	34 days	908

*Electrocardiography was performed once daily. Ten serial electrocardiographic tracings were printed over a period of 30 minutes every morning.

Results

In these 10 wethers a total of 5359 PVC's were actually counted and documented on a 12-lead surface electrocardiogram. The morphological characteristics of PVC's on the first and last day of PVC exposure were analyzed separately in every wether in order to detect any possible changes in PVC morphology (see tables 2-6).

Table 3.2. PVC exposure on the first and last day of study

Sheep Number	PVC's on 1st day	PVC's on last day
1	55	55
2	14	16
3	80	80
4	16	18
5	17	21
6	13	14
7	118	135
8	16	19
9	17	14
10	27	31
Total:	373	403

Table 3.3. PVC QRS duration on the first and last day of study

Sheep number	**Mean QRS duration on 1st day**	**Mean QRS duration on last day**	**Difference***
1	0.038	0.06	0.022
2	0.040	0.07	0.030
3	0.042	0.08	0.038
4	0.040	0.06	0.020
5	0.038	0.08	0.042
6	0.040	0.06	0.020
7	0.038	0.07	0.032
8	0.04	0.07	0.030
9	0.038	0.06	0.022
10	0.038	0.08	0.042

* $p = 0.000001$ (paired t-test)

Mean QRS duration of PVC's on first day= 0.0392 (95% CI: 0.038-0.040).

Mean QRS duration of PVC's on last day= 0.069 (95% CI: 0.06-0.08).

In this study three changes were noted in PVC morphology between the first and last day of PVC exposure. First, the QRS duration of the PVC's increased (see table 3.4), secondly, notching appeared in the QRS complexes of the PVC's (see table 5), and lastly, the isoelectric ST-segments of the PVC's disappeared (see table 6).

Table with graph 3.4. Increase in PVC QRS duration during chronic PVC exposure

Sheep number	Number of PVC's >0.06s on 1st day of study	Number of PVC's >0.06s on last day of study	Difference*
1	20	20	0
2	1	15	14
3	8	48	40
4	4	16	12
5	4	18	14
6	2	10	8
7	32	130	98
8	3	18	15
9	3	13	10
10	3	30	27

*p = 0.013 (paired t-test).

O.R= 13.93 (Odds ratio that the QRS duration of PVC's will increase from < 0.06 s on the first day of PVC exposure to > 0.06 s on the last day of PVC exposure).

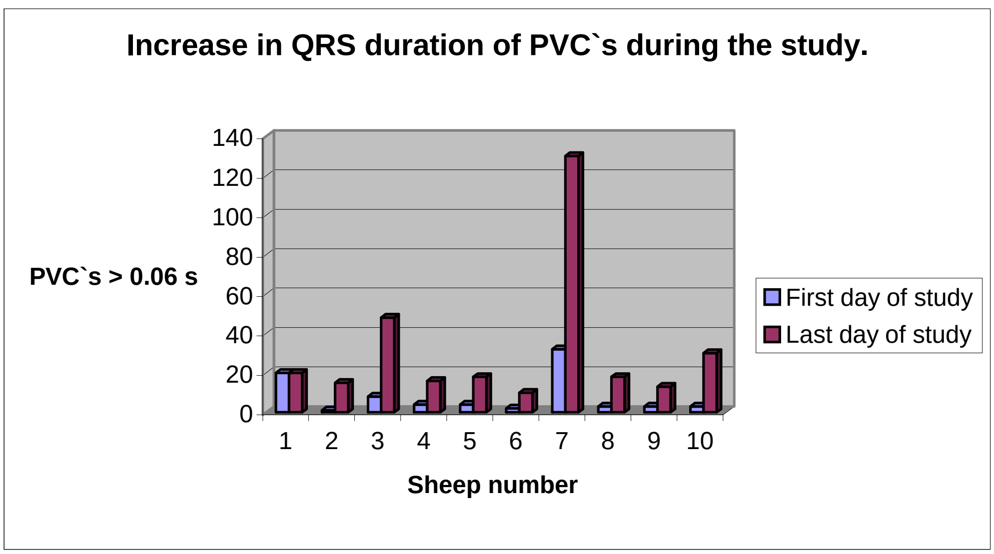


Table with graph 3.5. PVC's with notching of QRS complexes

Sheep number	Number of PVC's with notching on 1st day	Number of PVC's with notching on last day	Difference*
1	2	2	0
2	0	9	9
3	3	3	0
4	1	10	9
5	1	11	10
6	1	7	6
7	9	81	72
8	2	9	7
9	1	8	7
10	3	22	19

*p = 0.034 (paired t-test).

O.R = 11.17 (Odds ratio that PVC's will have notching of their QRS complexes on the last day of the study).

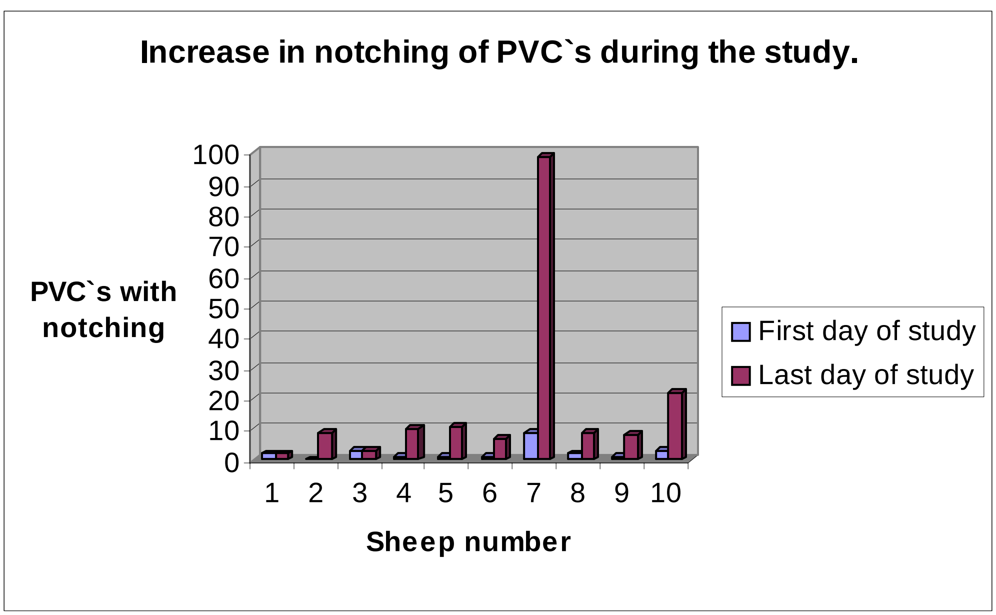
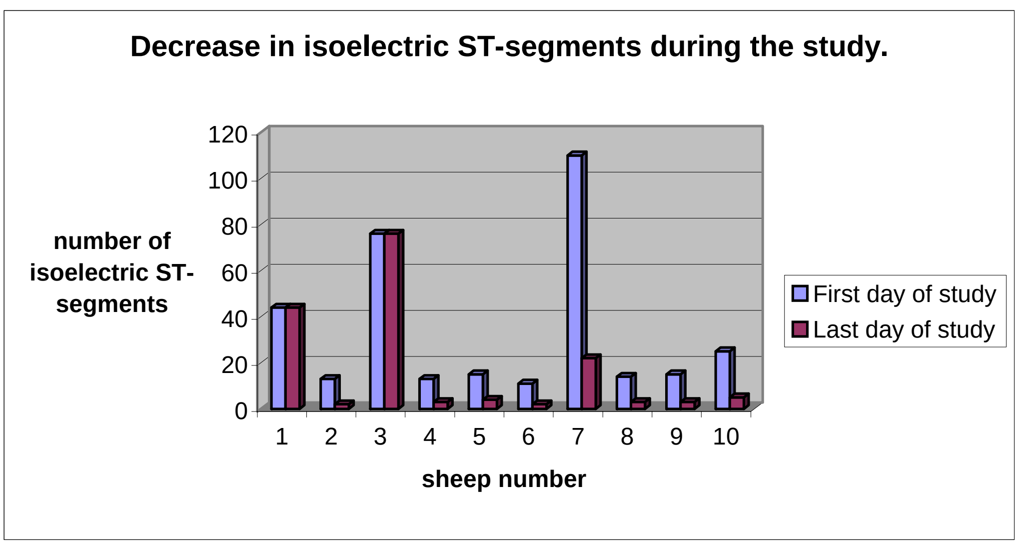


Table with graph 3.6. Number of PVC's with isoelectric ST-segments

Sheep number	Number of PVC's with isoelectric ST-segments on first day	Number of PVC's with isoelectric ST-segments on last day	Difference*
1	44	44	0
2	13	2	11
3	76	76	0
4	13	3	10
5	15	4	11
6	11	2	9
7	110	22	88
8	14	3	11
9	15	3	12
10	25	5	20

*p = 0.031 (paired t-test).

O.R = 12.86 (Odds ratio that the isoelectric ST-segment of the PVC's will disappear at the end of the study).



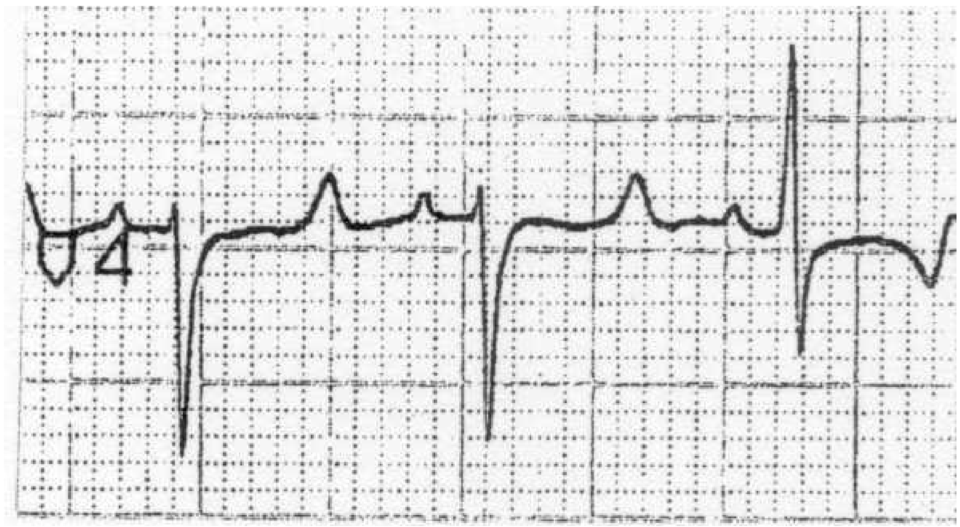


Figure 3.1. An example of an uncomplicated PVC occurring in the normal ovine heart during the first day of being subjected to PVC's. The third beat in this tracing from lead V4 is a PVC. Note the narrow QRS complex, with a duration of 40 msec and the isoelectric ST-segment. No notching of the QRS complex is present.

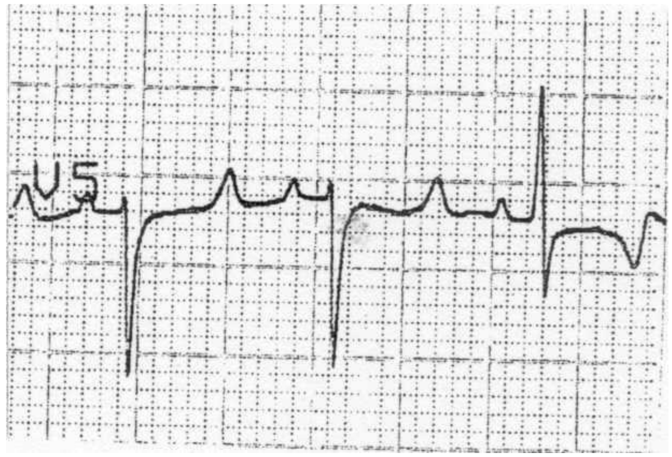


Figure 3.2. Another example of an uncomplicated PVC in the ovine heart, this time seen in lead V5. The third beat in the tracing is a PVC. Note once again the narrow QRS complex with no notching and the isoelectric ST-segment.

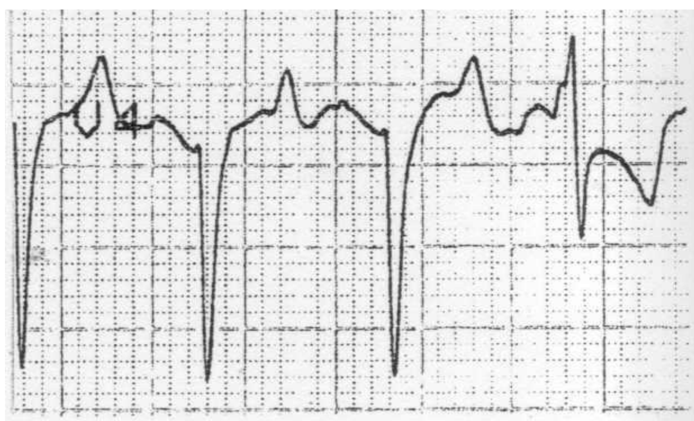


Figure 3.3. This tracing was taken from lead V4 from the same sheep as in figure 3.2, but this time after 14 days of exposure to PVC's. Now we see changes, possibly indicative of myocardial pathology. The third beat is a PVC. Note the notching of the QRS complex, the QRS complex is much broader than in figure 3.2, with a duration of 80 msec. Note also the prominent loss of the isoelectric ST-segment.

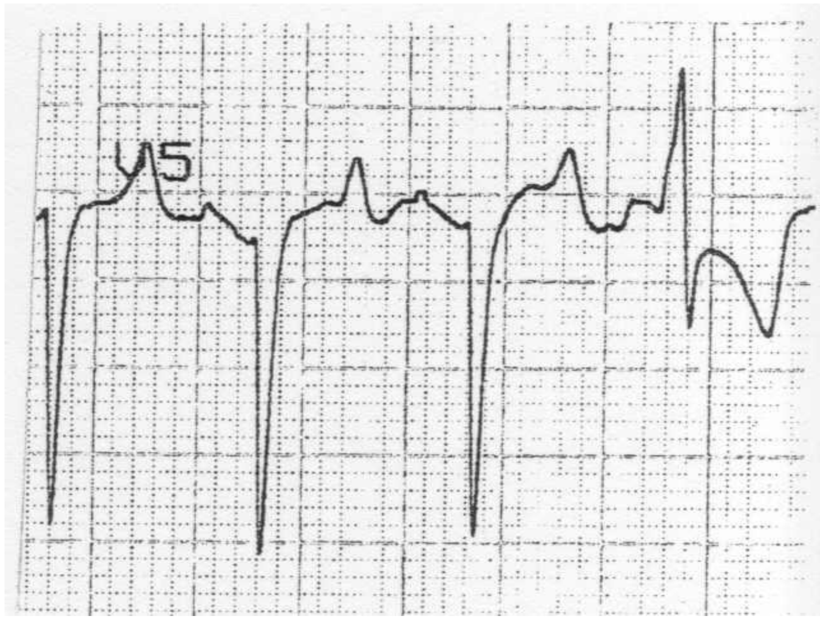


Figure 3.4. Tracing from lead V5 from the same sheep as in figure 3.3, also after 14 days of exposure to PVC's. Note once again the broader QRS complex with notching and loss of the isoelectric ST-segment, features suggestive of a complicated PVC.

Discussion

In all 10 wethers (with a total of 5359 PVC's counted) the following was seen. At the beginning of the study (during the first day) the PVC's had the following characteristics (see figures 3.1 and 3.2):

1) The QRS duration did not exceed 60 msec.
2) There was no notching of the QRS complexes.
3) The ST-segments were isoelectric.

During the course of the study, certain changes were noted in the PVC's (see figures 3.3 and 3.4):

1) The QRS duration prolonged to > 60 msec.
2) Notching of the QRS complexes appeared.
3) The isoelectric ST-segments disappeared.

A very clear and consistent change was thus seen in the morphology of ovine PVC`s in all the animals exposed to prolonged periods of PVC`s. We started the study with 10 normal sheep. The question that has arisen now is whether these 10 heart are still normal, as the morphological characteristics of "complicated" PVC`s has appeared. This question will be answered in the following chapter when these hearts will be examined histologically.

References

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