Distribution of Cardiac Sympathetic Nerves

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DISTRIBUTION of cardiac sympathetic nerves in the heart has been studied by anatomical and physiological methods. SCHUMACHER¹⁾ reported that the right cardiac nerve supplied the right atrium and ventricle and the left nerve the left side of the heart. At present, however, it is generally believed²⁻⁴⁾ that each ventricle is supplied by the bilateral sympathetic nerves, predominantly by the nerves of the corresponding side. In the author's laboratory, OKINAKA,⁵⁾ IKEDA⁶⁾⁷⁾ and their coworkers confirmed a thick branch of the right cardiac nerve which reached the anterior part of the left ventricle, passing behind the pulmonary artery.

A marked decrease was demonstrated in the norepinephrine concentration in the heart following bilateral cervical sympathectomy in the previous studies.⁸⁾ From these studies, it is very conceivable that unilateral cardiac sympathectomy may induce a decrease in the norepinephrine content of the area supplied by the corresponding sympathetic nerve. Based on this assumption, the norepinephrine content was determined in various portions of the heart after unilateral cervical sympathectomy, so that the distribution of cardiac sympathetic nerves might be clarified.

MATERIALS AND METHODS

Thirty dogs, weighing 4 to 15 kg, were used. Unilateral cervical sympathectomy was performed on them under thiopental sodium anesthesia (0.03–0.05 g/kg of body weight). At the same time with this operation, the superior, middle, and inferior cervical sympathetic ganglia were resected on the left side in 15 dogs and on the right side in the remaining 15.

The dogs were sacrificed at 14, 21, or 28–30 days after the operation and the norepinephrine content

Fig. 1. As indicated in this figure, the norepinephrine concentration was determined separately in the anterior portion and the postero-lateral portion of the left ventricle, the right ventricle and the ventricular septum.

was determined in both atria, both ventricles, and ventricular septum. The norepinephrine concentration was determined separately in the anterior portion and the postero-lateral portion of the left ventricle (Figure 1.). The method used for determination of norepinephrine was the same as described in the previous report.

The results were compared statistically with those obtained from the intact dogs studied previously.

RESULTS

1. Right cervical sympathectomy.

The norepinephrine concentration determined after right cervical sympathectomy is summarized in Table I.

The norepinephrine concentration was decreased markedly in both atria ($p < 0.001$) 14 and 21 days following the operation. It showed a slight recovery in both atria on the 28th–30th postoperative day ($p < 0.1$).

It exhibited a statistically significant de-

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TABLE I CHANGES IN NOREPINEPHRINE CONCENTRATION AFTER RIGHT CARDIAC SYMPATHECTOMY

Post-operative Day	No. of Dogs	Right Atrium ($\mu\text{g/g}$)	Left Atrium ($\mu\text{g/g}$)	Right Ventricle ($\mu\text{g/g}$)	Left Ventricle (Anterior Portion) ($\mu\text{g/g}$)	Left Ventricle (Postero-lateral Port.) ($\mu\text{g/g}$)	Ventricular Septum ($\mu\text{g/g}$)
Normal Dog	8	$0.811 \pm 0.057^*$	0.803 ± 0.055	0.626 ± 0.044	0.624 ± 0.065	0.610 ± 0.039	0.619 ± 0.055
14	8	0.471 ± 0.064	0.493 ± 0.075	0.269 ± 0.059	0.489 ± 0.069	0.598 ± 0.042	0.543 ± 0.060
21	4	0.490 ± 0.016	0.491 ± 0.010	0.301 ± 0.016	0.496 ± 0.020	0.607 ± 0.021	0.577 ± 0.011
28-30	3	0.560 ± 0.047	0.576 ± 0.029	0.367 ± 0.047	0.521 ± 0.015	0.612 ± 0.008	0.582 ± 0.044

* mean, + standard error of the mean.

TABLE II CHANGES IN NOREPINEPHRINE CONCENTRATION AFTER LEFT CARDIAC SYMPATHECTOMY

Post-operative Day	No. of Dogs	Right Atrium ($\mu\text{g/g}$)	Left Atrium ($\mu\text{g/g}$)	Right Ventricle ($\mu\text{g/g}$)	Left Ventricle (Anterior Portion) ($\mu\text{g/g}$)	Left Ventricle (Posterolateral Portion) ($\mu\text{g/g}$)	Ventricular Septum ($\mu\text{g/g}$)
Normal Dog	8	$0.811 \pm 0.056^*$	0.803 ± 0.055	0.626 ± 0.044	0.624 ± 0.065	0.610 ± 0.019	0.619 ± 0.055
14	8	0.481 ± 0.036	0.481 ± 0.034	0.543 ± 0.046	0.350 ± 0.031	0.160 ± 0.022	0.440 ± 0.042
21	4	0.518 ± 0.038	0.498 ± 0.041	0.529 ± 0.027	0.373 ± 0.015	0.156 ± 0.016	0.432 ± 0.020
28-32	3	0.525 ± 0.054	0.521 ± 0.042	0.577 ± 0.025	0.379 ± 0.015	0.173 ± 0.008	0.437 ± 0.029

* mean, + standard error of the mean.

crease also in the anterior portion of the left ventricle ($p < 0.01$) and in the ventricular septum ($p < 0.05$), no significant change in the postero-lateral portion of the left ventricle ($p < 0.6$) and slight recovery in the right ventricle ($p < 0.05$).

2. Left cervical sympathectomy.

The results obtained are shown in Table II. A decrease in the norepinephrine concentration was marked in the right as well as in the left atrium on the 14th postoperative day ($p < 0.001$). An insignificant recovery of the concentration was found in both atria ($p < 0.2$) on the 28th-30th day following the operation.

The norepinephrine concentration showed a marked decrease in the ventricular septum and the anterior and postero-lateral portions of the left ventricle and a statistically significant decrease in the right ventricle ($p < 0.01$) when determined 14 days following the sympathectomy. It exhibited a slight, insignificant recovery toward the preoperative level in the right ventricle and in the anterior portion of the left ventricle ($p < 0.2$).

DISCUSSION

Many anatomical and physiological studies have been made on the distribution of sympathetic nerves in the heart. It is generally believed that each ventricle is innervated bilaterally, although it is supplied strongly by the sympathetic nerve on its own side.²⁻⁷⁾

It has been proved in the present study that the norepinephrine concentration in the right ventricle showed a more marked decrease after right cervical sympathectomy than after left cervical sympathectomy. This suggests that the sympathetic nerves of both sides may be distributed in the right ventricle, although innervation of the right sympathetic nerve may be preponderant there. This finding is in good agreement with the results reported by previous investigators.²⁻⁴⁾⁹⁾

Similarly, it is considered that the cervical sympathetic nerves of both sides reach the anterior portion of the left ventricle, since the norepinephrine concentration in this portion revealed a significant decrease after bilateral

cervical sympathectomy. It was demonstrated that there was a thick branch of the right cardiac nerve which reached the anterior portion of the left ventricle.²⁻⁷⁾ It may be postulated, however, that the left cervical sympathetic nerve exerts a stronger influence on the anterior portion of the left ventricle than the right nerve, since a profounder decrease was induced in norepinephrine concentration by left cervical sympathectomy than by right one.

On the other hand, it is interesting to note that the norepinephrine concentration was decreased in the postero-lateral portion of the left ventricle only after left cervical sympathectomy. This portion is considered to be supplied exclusively by the left sympathetic nerve. Macroscopically, it is clear that a branch of the left cardiac nerve,¹⁰⁾ named the posterior ventricular nerve by Okinaka and his coworkers,⁶⁾¹¹⁻¹⁴⁾ reaches this portion.

So far the ventricular septum is concerned, it is suggested from the results of the present study that this portion may be supplied bilaterally by the left cervical sympathetic nerve with predominance. As is well known, the stimulation of the left cardiac nerve causes the shortening of the P-R interval and ectopic beats.¹⁵⁻¹⁷⁾

A significant decrease in the norepinephrine concentration was found in both atria following unilateral cervical sympathectomy on either side. This result may be related to the cardiac plexuses.

As stated in the previous report, no particular tendency was observed in the norepinephrine concentration for 50 days following bilateral cervical sympathectomy. On the other hand, the norepinephrine concentration showed a slight recovery in the right and left atria ($p < 0.1$) and the right ventricle ($p < 0.05$) 28-30 days following right cervical sympathectomy. It exhibited also a slight, statistically insignificant recovery in both atria ($p < 0.2$), the right ventricle ($p < 0.2$) and the anterior portion of the left ventricle ($p < 0.2$) on the 28th-30th day after left cervical sympathectomy. It seems that the cardiac sympathetic nerve of the intact side may compensate the function of the counterpart of the opposite side which has undergone unilateral cervical

sympathectomy.¹⁸⁾

SUMMARY

1. The norepinephrine concentration was determined fluorimetrically in various portions of the heart of 30 unilaterally sympathectomized dogs. The operation was performed on the left side in one half of the dogs and on the right side in the other half.

2. The norepinephrine concentration showed a significantly marked decrease in both atria, the right ventricle, the ventricular septum, and the anterior portion of the left ventricle following unilateral cervical sympathectomy on either side. It exhibited also a marked decrease in the postero-lateral portion of the left ventricle following left cervical sympathectomy. It was not affected, however, in the same portion of the left ventricle by right cervical sympathectomy.

3. From the results above mentioned, it was postulated that the postero-lateral portion of the left ventricle might be supplied exclusively by the left cardiac sympathetic nerve and that the other portions of the heart might be innervated bilaterally with some unilateral preponderance. The right ventricle was assumed to be supplied predominantly by the right cervical sympathetic nerve, while the anterior portion of the left ventricle and the ventricular septum were considered to be innervated predominantly by the left nerve.

4. It seems that the cardiac sympathetic nerve of the intact side may compensate the function of the corresponding nerve of the other side where unilateral cervical sympathectomy has been performed. This presumption has been made, since the norepinephrine concentration showed a slight tendency toward the preoperative level 28-30 days following unilateral cardiac sympathectomy.

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