Reports

Distribution of Nerve Endings in the Pulmonary Artery of the Cat

Abstract. The density distribution of nerve endings in the wall of the extrapulmonary portion of the cat's pulmonary artery was studied in serial sections after staining by a supravital methylene blue procedure. The greatest concentration of endings occurred at the bifurcation, in the adjacent parts of the pulmonary artery, and in its right and left main branches. The morphology and distribution of these endings is consistent with a pressoreceptor function.

Recent electrophysiological (*1–3*) and pharmacological (*4*) evidence has indicated the presence of sensory receptor endings of pressoreceptor type in the wall of the pulmonary artery. Although the presence of branched sensory nerve endings in the extrapulmonary portion of the pulmonary artery has been known for some time (*5*), no critical study of their distribution has been undertaken. This report presents the results of a histological survey of the density distribution of nerve endings in the extrapulmonary part of the cat's pulmonary artery.

Ten adult cats were used. Nerve endings were stained by a modification of the supravital methylene blue technique (*6*), after the removal of excess fat and perivascular connective tissue. Transverse serial sections (25 μ thick) were cut at intervals of 125 or 250 μ commencing at the pulmonary valve and progressing to the origin of the lobar arteries. Measurements of the maximum and minimum internal and external diameters of the pulmonary artery and its two main branches were made with a net micrometer eyepiece at an overall constant magnification of 35 diameters. The vessel wall appeared irregular in transverse sections. Since the sections did not have the shape of a circle or ellipse, it was thus necessary to obtain a mean radius value in order to compute the area. The effective vascular area expressed in arbitrary units was calculated from the expression:

$$A = \pi\left(\frac{R_{\max} + R_{\min}}{2}\right)^2 - \pi\left(\frac{r_{\max} + r_{\min}}{2}\right)^2$$
$$= \pi\,(\bar{R}^2 - \bar{r}^2)$$

Where $\bar{R}$ and $\bar{r}$ represent the mean external and internal radii. The nerve density of each section was determined and expressed as the number of endings per unit of vascular area. The level of each section was referred to the bifurcation as ascertained histologically.

There was no apparent change in vascular area from the pulmonary valve to the beginning of the bifurcation. The sum of the areas of the right and left pulmonary branches was less than that of the main pulmonary artery. The endings appeared as fine, discretely coiled, irregularly branched terminations lying wholly within the media or extending into the medio-adventitial junction. A typical density distribution of afferent nerve endings in an adult cat is shown in Fig. 1. The greatest density of endings occurred in the region of the bifurcation and in the initial portion of the right and left main pulmonary branches. Diminishing density values were noted proximally along the pulmonary artery, and distally along the right and left branches. Very few endings were present at the pulmonary valve or at the hilar regions. In seven cats the main right branch appeared to have a greater density of endings than the left branch. The distribution was equal in the three other animals.

With the method of investigation employed in this study, it was not possible to differentiate quantitatively between visceral afferent or visceral efferent nerve endings. However, three lines of evidence suggest that these nerve endings are probably afferent in nature. The morphology of these extrapulmonary endings is very similar to the pressoreceptor endings in the carotid sinus (*7*) and common carotid artery (*8*), and to the single pressoreceptors isolated by Bianconi and Green (*1*) from the pulmonary artery of the cat. These workers relied on silver impregnation techniques. No endings were seen in adjacent segments of ascending aorta, although the presence of smooth muscle in this site is well known. These observations suggest that the pulmonary endings are of a nonefferent type. Further evidence of the probable pressoreceptor nature of these endings is seen from the pulmonary artery catheter studies of Bevan (*9*) in which the maximum reflexogenic response to lobeline injection, which stimulates pulmonary pressoreceptors (*4*), is seen at the pulmonary bifurcation, but is absent from the right and left main branches at the hilar level. Such a distribution corresponds to the nerve ending density curve in this study. The presence of moderate numbers of nerve endings in the main pulmonary artery of the cat (see Fig. 1) is of interest in view of the findings of Coleridge *et al.* (*3*), who consider the main trunk to be

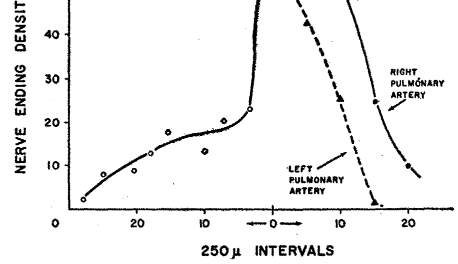

Fig. 1. Typical density distribution of nerve endings in the pulmonary artery of the cat. (Supravital methylene blue. Serial section at 250-μ intervals.) The values represent the density expressed as endings per unit of vascular area.

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Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

devoid of sensory receptors in the dog.

It is concluded from this histological study that the nerve endings in the cat's pulmonary artery are most concentrated at the bifurcation and are also found to a significant extent in the adjacent region of the main pulmonary artery and in initial parts of its right and left branches.

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Beryllium and the Growth of Bush Beans

Abstract. Beryllium in nutrient solution inhibited the growth of bush beans. The initial symptom was retarded root development. Although severe stunting of plants occurred, the foliage retained normal color. Roots accumulated beryllium. Increased beryllium concentrations decreased calcium in roots, stems, leaves, and fruits, and also decreased magnesium in roots and stems. Phosphorus was slightly increased in stems, leaves, and fruit.

Because of its unique properties, beryllium is a suitable constituent of power sources for nuclear- and chemical-powered propulsion devices. This element is toxic to animals (*1*). Our interest in Be developed upon considering whether or not its dispersion into the natural environment might also have injurious effects on higher plants. Observations of beneficial and detrimental effects of Be on plant growth processes have been reported (*2*).

Ten-day-old bush bean seedlings (*Phaseolus vulgaris,* "Tendergreen") were transferred from sand culture to aerated, nutrient solutions containing 0, 0.5, 1.0, 2.0, 3.0, or 5.0 ppm Be. The base nutrient solution also contained $2.25 \times 10^{-3}M$ KNO_3, KH_2PO_4, and $MgSO_4$, $1 \times 10^{-3}M$ NH_4NO_3, and $3.75 \times 10^{-3}M$ $Ca(NO_3)_2$. Micronutrient levels were 0.05 ppm B, 0.01 ppm Mo, 0.5 ppm Mn, 0.05 ppm Zn, 0.02 ppm Cu, and 2.5 ppm Fe(EDDHA). The *p*H of this nutrient solution was buffered at 5.3 ± 0.5. All of the Be treatments had four replicates. Each replicate consisted of two plants grown in 3.6 liters of nutrient solution that was renewed five times during 48 days of plant growth on the Be treatments. At harvest the plants were divided into roots, stems, leaves, and fruit.

An inhibiting effect of Be on the growth of bush beans was evident from the dry weights of the plant parts (Fig. 1). The mean total dry plant weights were 60.2, 40.2, 35.5, 20.6, 14.5, and 7.3 g from the 0, 0.5, 1.0, 2.0, 3.0, and 5.0 ppm Be treatments, respectively. Visual symptoms of Be inhibition first were observed on the roots of bean seedlings transferred to nutrient solution containing 3.0 and 5.0 ppm Be. The roots turned brown within 5 days after Be treatment was started, and the roots failed to resume normal elongation. More than normal numbers of stubby rootlets developed from pudgy, secondary roots. Stunting of plant foliage became apparent within 10 days of exposure to the higher Be treatments; however, the foliage continued to retain natural color at all Be concentrations during the 48-day treatment period. These abnormal symptoms became progressively more severe as the Be concentration in the nutrient solution increased from 0.5 to 5.0 ppm. Earlier flowering occurred for plants grown at the higher Be treatments, which was reflected in the dry weights of fruits (Fig. 1). Although the bush beans grown at 0 and 0.5 ppm Be set more fruit pods, these pods were much less mature when harvested than were the fruit pods produced at the higher Be treatments.

Table 1 shows the concentrations of Be, Ca, Mg, and P in parts of bush beans. Concentrations of Be, Ca, and Mg were measured by emission spectrograph. Phosphorus was determined by the method of Allen (*2*). Beryllium accumulated in the root tissues. Among the aerial parts, the leaves accumulated the highest concentrations of Be; relatively small levels of Be accumulated in the bean fruits. Uptake of Be was linear with respect to the concentration of Be in the nutrient solution. Calcium was decreased in roots, stems, leaves, and fruits as the Be concentration was increased in these plant parts. Increased

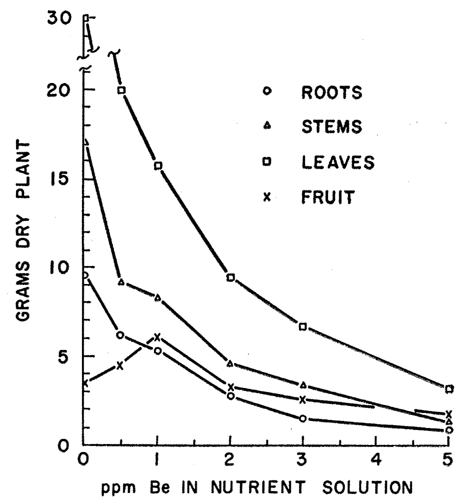

Fig. 1. Effect of increasing concentrations of Be in nutrient solution on the dry weights of parts of bush beans grown 48 days on Be treatments (mean of four replicates).

Be concentrations decreased the Mg concentration in roots and stems but did not alter Mg in leaves and fruits. The concentration of P in roots was reduced at the 5-ppm Be level but was not affected at the lower treatment levels. In other plant parts, the P concentration tended to increase as the Be concentration increased. The percent of total mineral ash in dry plant tissues

Table 1. Concentrations of Be, Ca, Mg, and P in parts of bush beans grown on Be-treated nutrient solution (mean of four replications).

Be in solution (ppm)	Conc. of element in dry plant tissue (mg/g)			
	Be	Ca	Mg	P
		Roots		
0	0	5.2	5.6	18.0
0.5	0.271	3.5	6.5	18.4
1.0	0.431	4.5	5.8	20.2
2.0	0.668	4.3	3.6	18.6
3.0	0.978	3.7	2.3	19.4
5.0	1.076	2.6	2.0	13.1
		Stems		
0	0	8.5	1.9	6.8
0.5	0.004	6.8	1.9	7.2
1.0	0.006	5.5	2.1	7.2
2.0	0.015	4.0	1.8	9.2
3.0	0.018	3.5	1.7	8.7
5.0	0.024	3.4	1.8	8.4
		Leaves		
0	0	22.1	4.2	10.8
0.5	0.008	31.4	6.1	11.1
1.0	0.016	30.1	6.3	10.9
2.0	0.034	19.7	6.7	15.2
3.0	0.042	18.0	6.7	16.0
5.0	0.070	17.9	6.8	15.4
		Fruit		
0	0	4.8	2.6	6.3
0.5	0.001	5.1	2.7	6.9
1.0	0.002	4.6	2.6	6.9
2.0	0.004	3.9	2.6	7.8
3.0	0.005	2.8	2.5	8.8
5.0	0.006	2.2	2.7	10.2