THE BARORECEPTOR REFLEX EMANATING FROM THE CAROTID SINUS AND COMMON CAROTID ARTERY OF THE SHEEP

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Abstract of a Thesis Presented in Partial Fulfilment of the Requirements for the Degree of Master of Science

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by Karen T. Ball

The aim of this project was to improve understanding of the role of the common carotid arterial baroreceptor mechanism in controlling peripheral blood pressure in the sheep. The responses to clamping of one or both common carotid arteries were examined under chloralose anaesthesia with the vagus nerves intact and after they had been sectioned.

Unilateral clamping of a common carotid artery immediately reduced the mean blood pressure and pulse pressure in the ipsilateral carotid sinus and raised the peripheral mean blood pressure and pulse pressure. The failure of sinus pressures to show any recovery in the clamped vessel suggests that there was minimal flow through anastomoses into the occluded artery. Bilateral clamping of the common carotid arteries reduced the mean blood pressure within both carotid sinuses to a lower level than unilateral clamping, but raised the peripheral mean blood pressure and pulse pressures to a greater degree. This pressor response was interpreted as being due to the larger population of baroreceptors detecting the low carotid sinus pressures during bilateral occlusion.

To test whether there was a tendency for common carotid arterial clamping at different levels to produce different reflex responses of peripheral blood pressure, the carotid arteries were occluded at the caudal, mid- and cranial cervical levels. There was a trend towards a greater rise in peripheral mean blood pressure during caudal clamping compared with cranial clamping. This too may be due to a larger population of baroreceptors detecting the low carotid sinus and common carotid arterial pressures and suggests baroreceptors are distributed in regions of the common carotid artery caudal to the sinus.

In one third of the sheep, clamping the left common carotid artery caused a greater rise in peripheral mean blood pressure than clamping of the right vessel. Possible reasons for this include the presence of a larger population of baroreceptors in the left artery than the right and differences in the sensitivity of receptors in the two vessels.

The variability of responses to clamping and vagotomy was emphasised by the responses of two sheep in which section of the right vagus nerve totally abolished the reflex response to right common carotid arterial occlusion. Since in these animals neither the size of the baroreceptor population nor its sensitivity appeared to be responsible, a conclusion consistent with the evidence is that the baroreceptors in the vessel were innervated by the recurrent laryngeal or vagus nerves. Overall in the experiments, bilateral vagotomy enhanced the peripheral mean blood pressure and pulse pressure responses to clamping the common carotid arteries in keeping with a loss of the input from the aortic arch and cardio-pulmonary baroreceptors.

Histological evidence of the distribution of sensory areas along the common carotid artery was obtained for three discrete areas (A, B and C). It is suggested that baroreceptors located in the common carotid artery may be less sensitive than those in the carotid sinus region because of the low elastin content and lack of tunica medial thinning at the sites of carotid arterial baroreceptor innervation.

This thesis is dedicated to those persons who
thrust challenges upon me, and also those
who gave me support; but most of all to
those rare and precious individuals who
provide both caring and challenge.

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LIST OF ABBREVIATIONS

A	Arterial
BSA	Bovine serum albumin
CCA	Common carotid artery
Cd	Caudal position (middle of fifth cervical vertebra)
Cn	Cranial position (cranial pole of second cervical vertebra)
DAB	Diaminobenzidine
ECA	External carotid artery
fp	Facing page
G	Ganglion
Int	Intact
L	Left
Md	Mid position (caudal pole of third cervical vertebra)
N	Nervus
n	Number of animals, unless otherwise stated
NFA	Nerve fiber area
NNFA	Non-nerve fiber area
No.	Number
NSE	Neuron specific enolase
OG	Occipital group
PBS	Phosphate buffered saline
R	Right
SPG	Sucrose-potassium-phosphate glyoxylic acid
Vn	Vagus nerve

Only simpletons find things absolutely clear.

Alexander Solzhenitsyn
August 1914

CHAPTER 1

INTRODUCTION

The concept that the cardiovascular system is regulated by neural reflexes originating from the great vessels and heart is more than 100 years old, but its importance was probably not fully appreciated until Hering discovered the carotid sinus baroreceptor reflex in 1923. Subsequently, intense study of this subject has led to the present recognition of the central role of the arterial baroreflexes in circulatory control.

Baroreceptors are stretch receptors predominantly located in the adventitia of the carotid sinus and aortic arch, and the frequency of firing of these receptors varies directly with both the mean blood pressure and the rate of change of blood pressure. Afferent signals pass to nuclei in the floor of the fourth ventricle, where, by a system of interneurons, an increase in baroreceptor impulses results in reflex inhibition of sympathetic adrenergic efferents to the cardiovascular system and reflex stimulation of the cardiac vagus nerve, leading to a decrease in systemic pressure. Baroreceptors are tonically active when blood pressure is normal and, therefore, a decrease in blood pressure causes a reduction of baroreceptor impulses and a rise in blood pressure to its normal level (Kircheim, 1976).

Heymans and Neil (1958) commented that "the temporary and incomplete loss of baroreceptor activity caused by carotid occlusion causes such an obvious hypertension that it is used all over the world to demonstrate the sinus reflexes to students". This is the case at Massey University, where the dog was initially the subject of the physiology student. During an acute experiment on these animals, clamping of both the left and right common carotid arteries caused regular and reproducible moderate increases in blood pressure and heart rate. In addition, bilateral section of the vagus nerves could be relied on to enhance these responses significantly. These results are similar to those observed by other workers in this animal.

Difficulty in obtaining dogs caused the Physiology Department to substitute the sheep in this experiment. The change of species presented a major problem : unusual cardiovascular responses began to emerge from this experiment. In particular, sheep displayed poor blood pressure and heart rate rises upon bilateral common carotid arterial occlusion, a significant fall in basal blood pressure upon section of both the left and right vagus nerves and the failure of bilateral vagotomy to enhance the clamping response.

Since such atypical observations do not appear to have been reported in other species, the present project was instigated in order to explain these findings and improve the knowledge of the basic mechanisms involved in the control of blood pressure in sheep. This initially involved an anatomical review of the arterial supply of blood to the ovine cephalic circulation. The students' physiological observations were then examined and repeated under more suitable conditions of anaesthesia and further clamping protocols were subsequently undertaken in an attempt to clarify the carotid sinus baroreceptor mechanism in the sheep. The results from these latter experiments were suggestive of baroreceptors down the length of the common carotid artery and, because of this, the final component of this project was to study histologically the innervation of the ovine common carotid artery.