Cardiopulmonary vagal afferents in the monkey:
A survey of receptor activity*)

Kardiopulmonale Vagusafferenzen beim Affen:
Eine Übersicht über die Aktivität der Rezeptoren

I. H. Zucker and J. P. Gilmore

With 7 figures

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Summary

A survey was made of vagal afferents whose endings originated in cardiopulmonary areas of the Rhesus monkey. Recordings of action potentials from single fiber preparations of the left cervical vagus were made in both open and closed chest monkeys. A total of 425 receptors were identified in sixteen animals. These consisted of 347 pulmonary stretch receptors (one of which increased its discharge during expiration), 42 aortic baroreceptors, 4 ventricular pressure receptors, 1 epicardial ventricular receptor, 7 type A atrial receptors and 24 type B atrial receptors. The response of each cardiovascular receptor was tested by altering the stimulus for their discharge. Aortic and ventricular baroreceptors increased their discharge in response to an increase in blood pressure induced by intravenous norepinephrine. Type A atrial receptors did not increase their discharge in response to an increase in atrial pressure during intravenous administration of isotonic saline, while type B atrial receptors did. The discharge of the latter became continuous following the intravenous administration of veratridine sulphate (20 \( \mu \)g). It is concluded that the basic types of cardiopulmonary afferents exist in the non-human primate and that they respond similarly to those which have been demonstrated in lower species.

Stretch receptor endings located in the cardiopulmonary areas have been described both histologically and physiologically by various workers (14, 5, 20). The reflexes which are mediated by these endings are well known (20). However, the investigation of these receptors has been centered primarily on the dog and cat. In a recent study we described the discharge properties of type B atrial receptors in the Rhesus monkey (28). Recently, Rao et al. (21) have described atrial receptor activity in the Rhesus monkey. To our knowledge only one study has described the discharge characteristics of vagal cardiopulmonary stretch receptors in the subhuman primate (4) and this was a cursory survey in a small number of animals. Microscopic examination of receptors located in the atria and ventricles of

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monkeys has been done by Miller and Kasahara (14) and by Abrahám (1). These receptors are histologically similar to those described in lower species.

The present study was undertaken to survey the vagal cardiopulmonary stretch receptors in the Rhesus monkey and to document their discharge characteristics during resting conditions and during changes in their stimulus.

The results indicate that the characteristic types of vagal cardiopulmonary receptors are present in the monkey and that they have discharge patterns similar to those described for other species.

Methods

Sixteen young adult Rhesus monkeys of either sex, averaging 4.7 kg were used. After pretreatment with ketamine (8 mg/kg, i.m.; Ketaject) the monkeys were anesthetized with pentobarbital sodium (30 mg/kg, i.v.; Diabutal) and supplemental doses of anesthetic given as needed through the experiment. Both open and closed chest preparations were utilized. In open chest preparations the animals were ventilated using a positive pressure respirator (Harvard Apparatus) and either a left or transverse thoracotomy performed in the 4th intercostal space. The pericardium was incised to permit access to both atrial appendages. A thermistor was placed between the tracheal cannula and respirator to indicate the phase of respiration. A metal cannula was placed in the left atrium through the left atrial appendage and left atrial pressure (LAP) recorded using a Statham pressure transducer (P 23 Db) zeroed at the level of the left atrium. In some instances a transducer tipped catheter was used for the measurement of LAP (Millar, Houston, Texas). In closed chest preparations, a polyethylene catheter was passed down the right external jugular vein to the level of the right atrium for the measurement of central venous pressure (CVP). A transducer tipped catheter was placed in the ascending aorta via a femoral artery for the measurement of aortic pressure. The dynamics of our pressure recording system has been reported previously (28). A femoral artery and vein were cannulated for withdrawing blood and administering fluids and drugs. A standard limb lead Ecg was recorded. Rectal temperature was maintained at 37 °C with the aid of a thermistor (Yellow Springs) and water circulating heating pad.

Recording of single units from the cervical vagus were made as described previously (8) with modifications made for the monkey. Briefly, under a dissecting microscope the left cervical vagus was dissected free and desheathed. Twigs of the nerve were gently teased away from the main vagal trunk, cut centrally, and the distal end placed upon bipolar platinum-iridium electrodes. The potentials from the fibers were amplified as described previously (28). All signals were displayed on an ultra-violet oscillographic recorder (Honeywell Visicorder, 1858) and records were taken at a paper speed of 100 mm/sec. Pressure measurements and nerve discharge were quantified directly from the original recordings. All data were tabulated and statistical analysis done using a standard computer program.

Response characteristics of aortic and ventricular baroreceptors were tested by administering 1-norepinephrine intravenously (2-10 micrograms; Levophed). In order to alter the response of atrial type B receptors, plasma volume was first expanded with warm isotonic saline followed by withdrawal of blood until the LAP returned to control levels. In some preparations veratridine sulfate (10-20 μg) was injected intravenously to determine its effect on atrial receptor discharge. All records were taken during the expiratory pause. Each receptor