The Kidney and Hypertension

ARTHUR C. GUYTON, R. DAVIS MANNING, THOMAS E. LOHMEIER, and JOHN E. HALL

1. Introduction

From the earliest studies on kidney disease it was already apparent that the kidneys play a very important role in controlling arterial pressure. However, the mechanism or mechanisms by which the kidney affects pressure have remained unclear even to the present. All research workers have known of the obvious possibility that renal disease might cause retention of water and salt in the body and that excess volume could drive the circulatory system toward a higher level of activity, thus causing hypertension. Yet, even Bright (1836) in his classical studies on “Bright’s disease” noted vasospastic phenomena associated with renal hypertension, leading to the suggestion that renal hypertension might result from some circulating vasoconstrictor agent.

We now know that abnormal renal function can at times lead to retention of water and salt and at other times cause secretion of vasoactive agents, especially the renal hormone renin, and these two effects can occur independently of each other or together. Furthermore, both can raise the arterial pressure. Therefore, the present problem is not whether both effects occur but instead what is the quantitative significance of each. Furthermore, can either or both of them cause chronic hypertension? Or is either of them limited to causing only acute hypertension? These are some of the questions that we explore in this chapter.

Another important question is: What is the relationship of the renal pressure control mechanisms to the many nonrenal mechanisms for con-
Figure 1. Degree of activation, expressed in terms of feedback gain, of different pressure control mechanisms following a sudden change in arterial pressure. Note the rapid activation of the three nervous control mechanisms, the moderately rapid activation of several intermediate pressure control mechanisms, and the slow but extremely powerful activation of the renal blood volume-pressure control system. (Reprinted from Guyton, 1980.)

trolling pressure? In recent years, the effectiveness of the different pressure control mechanisms has been quantitated in two different ways. (1) The potency of each pressure control mechanism has been measured in terms of feedback gain. For instance, a pressure control mechanism that has a feedback gain of 5 is capable of correcting an abnormal arterial pressure 5/6th of the way back toward the control value. (2) The time course of the response of each pressure control mechanism has been studied to determine how rapidly it can correct the pressure abnormality and also whether or not the correction can last indefinitely. Figure 1 illustrates an approximate summary of what is known about the effectiveness of each of eight different important pressure control mechanisms. Several of these are related to kidney function, and others are nonrenal. Some of their characteristics are described the following.

1.1. Nervous Feedback Mechanisms

The most rapidly acting of the pressure control mechanisms are the nervous controls. That is, an abnormal pressure elicits signals from sev-