Mechanisms of Centrally Induced Pulmonary Edema

Lloyd D. Seager

Department of Pharmacology, University of Arkansas Medical Center, Little Rock, Arkansas, U.S.A.

A variety of factors involving the central nervous system have been shown to be associated with the development of pulmonary edema. In clinical experience...
Weisman (1939) and Cameron (1948) found pulmonary edema in nearly 70% of patients dying from traumatic or spontaneous intracranial hemorrhage. Baker (1957) studied 15 patients who had died from bulbar poliomyelitis. Ten of these had pulmonary edema and showed bilateral lesions of the dorsal nuclei of the vagus and medial reticular formation, while the 5 without pulmonary edema showed no central lesions. In animal experiments it has been found that pulmonary edema can be produced by an increased intracranial pressure (Campbell, Haddy, Adams, and Visscher, 1949), intracisternal injection of veratrine (Jarisch, Richter, and Thoma, 1939), intracisternal injection of a fibrinogen-thrombin mixture (Cameron and De, 1949), bilateral lesions of the vagal nuclei (Borison and Kovacs, 1959), discrete bilateral lesions of the preoptic areas of rats (Gamble and Patton, 1951), and bilateral injection of minute amounts of aconitine or veratrine into the preoptic areas of rats and dogs (Seager and Wood, 1962). While a neurogenic mechanism has often been postulated for the variously produced edemas of central origin, a systematic study of the circulatory parameters has usually yielded a hemodynamic explanation. In pulmonary edema in dogs resulting from the intracisternal injection of fibrin and thrombin Sarnoff and Berglund (1952) found elevations of pulmonary and systemic arterial and venous pressures along with a marked increase in peripheral resistance. Their findings indicate that the increased pulmonary pressures may result from a shift of volume from the peripheral vessels to the lungs as well as from failure of the left heart to maintain its output against the increased peripheral resistance. The edema associated with increased intracranial pressure was found by Campbell, Haddy, Adams, and Visscher (1949) to be associated with hypertension and bradycardia and they postulate that the slowing of the heart raises pulmonary venous pressures to a magnitude that produces capillary leakage and edema. Animals developed edema rapidly when the pulmonary venous pressures exceeded 20 mm Hg. Marie and Patton (1956) have postulated that preoptic pulmonary edema is a release phenomena in which an edema center caudal to the preoptic area becomes activated causing a massive sympathetic discharge and resulting in a shifting of blood volume from the systemic to the pulmonary circuit. Section of the splanchnic nerves or cord transection at C8 prevents the edema. Wood and Seager (1964) have found that the rapidly developing pulmonary edema in rats and dogs resulting from the bilateral injection of aconitine or veratrine into the preoptic areas or intracisternally is associated with a marked increase in pulmonary and systemic arterial and venous pressures. Pulmonary venous pressures as high as 45 mm Hg and systemic arterial pressures of 400 mm Hg have been attained in dogs in these experiments. Marked increases in total peripheral resistance often with diminished cardiac output were seen. Bradycardia was often present. Three factors, i.e., diminished cardiac output against the increased peripheral resistance, bradycardia and shunting of blood to the low pressure pulmonary circuit may individually or collectively account for the increased pulmonary venous pressures and the edema in these experiments. The pulmonary venous pressures recorded were usually well above 20 mm Hg, i.e., the critical level shown by Campbell and Visscher (1949) and Guyton, et al. (1959), for the development of pulmonary edema in the dog. The pressor responses and edema were largely abolished by administration of dibenzyline and other sympatholytic agents but not by atropine. The pressor responses to the intracisternal injection of veratrine or aconitine have been shown by Fadhel and Seager (1964) to be abolished also by the intracisternal injection of ganglionic blocking agents.
It would appear that most, if not all, of the centrally induced pulmonary edemas are associated with strong stimulation of the central sympathetic mechanisms. The widespread distribution of pressor areas would account for the variety of procedures that produce edema. The pioneer work of Hess (1954) and the extensive studies of Magoun, Ranson and associates (1938, 1940) have explored the hypothalamus and have found the most sensitive areas for producing blood pressure changes to be in the medial forebrain bundle, the lateral hypothalamus, the perifornical nucleus and the H field of Ford. More recently, Gutman et al. (1962) stimulated discrete areas of the brain stem of unanesthetized rabbits from the hypothalamus to the medulla and found both pressor and depressor areas distributed throughout the whole brain stem. Experiments to date indicate that the most active area for edema production is the discrete "edemagenic" center described by Marie and Patton (1959). The simultaneous stimulation of several pressor sites as by the intracisternal injection of veratrine or a thrombin fibrinogen mixture may however summate to give a pressure response as rapidly developing and as great in magnitude as those from the "edemagenic" center.

References


Pathogenesis of Postoperative Acute Pulmonary Edema of the Central Nervous Origin

Miyoshi Urabe
Department of Surgery, School of Medicine, University of Kanazawa, Kanazawa, Japan

Postoperative pulmonary edema usually experienced by surgeons was not only