INTRODUCTION

Hypoxic brain damage may occur in any situation where there is an inadequate supply of oxygen to nerve cells. It is therefore a potential hazard to any patient subjected to general anaesthesia, a severe episode of hypotension, cardiac arrest, status epilepticus and carbon monoxide intoxication. The eventual degree of clinical recovery will be determined by whether or not satisfactory resuscitation can be achieved before permanent brain damage ensues. Crises of this kind are not uncommon in clinical practice but the central question as to what duration of hypoxia defines the watershed between recovery of the tissues and extensive permanent injury has not been critically defined in man (Plum, 1973). The reasons for this include the lack of precise physiological data about the patients' cardiovascular and respiratory status at the time of crisis since the immediate priority is resuscitation, and therefore such basic information as the precise duration of the cardiac arrest or blood pressure and heart rate during severe hypotension is very rarely available. In such cases the neuropathological descriptions, however exhaustive, may well explain the final neuropsychiatric status of the patient but can at best indicate only tentatively the nature of the episode itself.

Matters are further complicated by the fact that post mortem examination of patients with severe hypoxic brain damage are usually carried out under warrant by the forensic pathologist, who often feels obliged to slice the unfixed brain in the mortuary. In these conditions it is impossible to recognize recent hypoxic brain damage even when subsequent histological examination shows severe and extensive neuronal necrosis (Graham, 1977). When the brain has been
properly dissected after adequate (up to 3 weeks immersion in buffered 10% formol saline), focal hypoxic brain damage of about 18-24 hours duration may just be recognizable but even an experienced neuropathologist may fail to identify diffuse hypoxic brain damage if it is less than some 3-4 days duration. The extent and severity of hypoxic brain damage can be identified and its distribution analyzed only by the microscopic examination of many large bilateral and representative sections of the brain. It is, however, often possible to establish that a patient has suffered hypoxic brain damage on the basis of a more restricted examination provided the pathologist knows that certain areas of the brain are selectively vulnerable and is familiar with the cytological and histological appearances of ischaemic nerve cell change (Brierley, 1976; Brown, 1977).

The identification of specific changes in nerve cells is made difficult in the human brain because of the frequent occurrence of histological artefacts. They are due partly to post mortem handling and to the slow penetration of fixative. Studies in experimental animals and in selected human material have shown that there is an identifiable process, namely ischaemic nerve cell change, which is considered to be the neuropathological common denominator in all types of hypoxia in which circulation is either sustained partially via collateral arteries or restored after a period of absolute ischaemia (Brierley, 1976; Brown, 1977; Garcia et al., 1977). More recently a further type of ischaemic nerve cell injury has been reported to occur in different forms of permanent, complete ischaemia (Arseño-Nunes et al., 1973; Kalimo et al., 1977; Jenkins et al., 1979a) but the significance of this remains uncertain and controversial (Agardh et al., 1981; Brierley and Brown, 1981).

It is not the intention to review all aspects of the pathology of hypoxic brain damage, but rather to concentrate on the main patterns of stagnant hypoxic damage that follow a global reduction in the supply of blood to the brain in both man and the experimental animal. There are two main types, viz. ischaemic in which there is a global arrest of cerebral blood flow, and oligaemic in which there is a global reduction in blood supply.

STAGNANT HYPOXIC BRAIN DAMAGE IN MAN

Ischaemic

A global arrest of blood flow to the brain is most commonly the result of cardiac arrest. This is usually a complication of some surgical procedure under general anaesthesia. If death occurs within 24-36 hours of the arrest, the brain may appear normal externally and on section (Figure 1). Microscopy, however reveals diffuse neuronal necrosis with a characteristic pattern of selective vulnerability. Thus the hypoxic brain damage is commonly greater within sulci than