HEAD INJURIES
and
THEIR MANAGEMENT

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PREFACE

In this monograph an attempt has been made to describe briefly the essentials in diagnosis and treatment of head injuries. The objective has been to make this knowledge easily accessible and of practical value to residents as well as to the practicing surgeon and physician. A representative bibliography has been added. At least three excellent monographs on acute head trauma are already available, one dealing with peacetime injuries and stressing their pathologic aspects (Evans, 1950), and the other two with war wounds of the skull and brain (Penfield, 1941; Matson, 1949). In addition many outstanding and much more comprehensive volumes on the subject of cranial and intracranial injury are at the disposal of the specialist (Munro, 1938; Gross and Ehrlich, 1940; Rowbotham, 1949; Brock, 1949), but these are mostly too extensive, and only too often unavailable, to be of immediate value to the doctor who must initially care for the patient and frequently decides upon subsequent management.

INTRODUCTION

In treating a patient with a head injury the doctor should decide whether he is dealing with a surgical or a nonsurgical (nonoperable) case, for all head injuries may be so divided.[68] To make such a decision one must have at least an acquaintance with the important surgical and nonsurgical lesions of the head and brain, and the clinical picture they produce. Certain well-established, conservative measures should be used in the treatment of every head injury keeping in mind that all cases are potentially surgical. Fortunately, apart from cases with obvious externally visible head wounds and their complications, only a small per cent of serious injuries, in peace time, will require surgery for an intracranial hematoma or other less common lesion.

The purpose of this monograph is to state in simple terms what may happen to the head and brain following an injury and how such lesions and their complications may be recognized and managed.

CONTENTS

1

THE MECHANISMS OF HEAD AND BRAIN INJURY

HEAD INJURIES

A knowledge of some of the mechanical factors involved in trauma to the head will aid one in understanding how various types of injury have very different effects upon the skull and its contents.[36, 37, 40, 88, 100]

An injury to the head may be either direct or indirect.

Direct Head Injury. There are many ways in which the head can be injured. The movable head may be struck by a large moving object that jars the entire brain and skull, or by a small object like a hammer that penetrates, causing local damage without a generalized effect. A mobile head can be thrown against an immovable object, e.g., a sidewalk, again producing an effect on the entire cranium and its contents.

An immovable head braced against the ground or other firm substance may be generally crushed or burst by a large object, or a relatively small area of skull and brain can be crushed, for instance, by a small projecting portion of a jeep when the vehicle rolls over on the patient's head. In this case as with a hammer wound there may be severe local brain

damage with no general effect on the brain and no loss of consciousness.

Other direct injuries can result from penetrating instruments, bullets or shell fragments.

Indirect Head Injury. Injury to the brain or intracranial blood vessels at times follows the application of force to other parts of the body as when one falls in a standing or sitting position or on some other area of the body. Brain injury may also occur when force is suddenly applied to the body by a rapidly moving object like an automobile or when, as a passenger in an automobile, one's head is thrown into violent motion on colliding with another car or on coming to a sudden stop.

BRAIN INJURIES

The type and degree of injury is of importance, for upon this will depend to a considerable extent what happens to the brain and other intracranial structures (see Gurdjian, *et al.*[37] and Rowbotham [88]).

The brain may be injured by:

1. Movement of the brain in relation to the skull.
2. Distortion of the skull.
3. Acute compression of the thorax.
4. Penetrating wounds (open head injury).

1. Injury by Movement of the Brain in Relation to the Skull. In closed head injuries the most important manner in which the brain is injured is by its movement in relation to the skull. The movement may be linear, that is in a straight line, or rotatory.

Brain Injury by Linear Movement. If the head is thrown into rapid motion in a straight line, the

skull ceases its movement first and this often occurs abruptly, especially if it comes into contact with a fixed object. The brain on the other hand for a short period continues its forward course and comes violently into contact with portions of the rigid skull or dural septa resulting in contusion or laceration. At the opposite pole to that contused, the brain in moving forward apparently creates an area of diminished pressure and a suction injury to cerebral tissue or blood vessels may result. At the same time vessels, especially veins crossing the subdural space, may be torn as the brain slides forward or backward in a straight line.

Similar injury takes place at the onset of a rapid movement of the head in a straight line, but in this case the skull is set in motion first and strikes the brain which has lagged behind in its motion. Thus a contusion may occur at the site of the blow, a contrecoup injury in the opposite hemisphere and at the same time petechial hemorrhages in the brain stem (Fig. 1).

The forces responsible for the above injuries will vary according to the rate of change of velocity with which the head is set in motion in a straight line—so-called linear acceleration—and to the abruptness with which motion ceases—deceleration (see under concussion).

Brain Injury by Rotation. A blow to the head usually causes some rotatory movement of the skull. The motion of the skull is secondarily transmitted to the brain which may be contused or lacerated by bony projections or dural septa at the onset or termination of rotation. Holbourn believes that injuries due to rotatory movement are caused by shear strain [40]

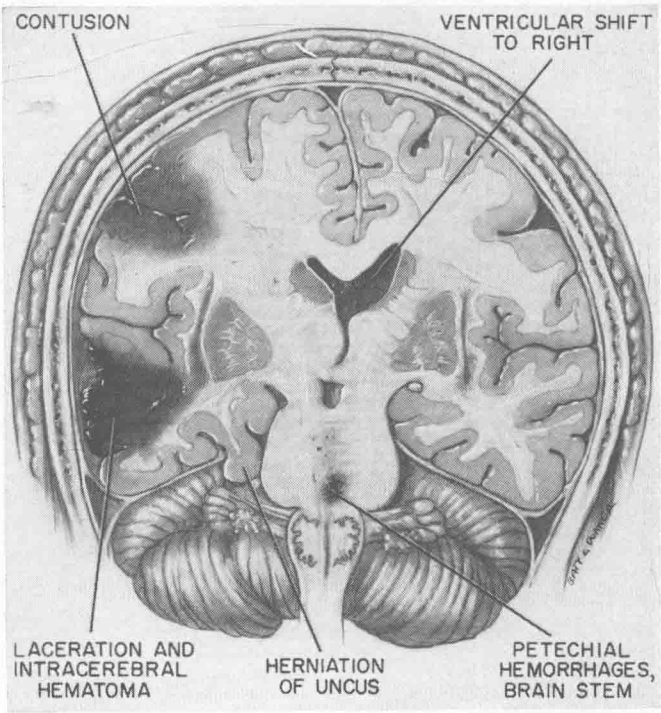

FIG. 1. With the exception of the intracerebral hematoma the lesions shown are nonsurgical (nonoperable).

that results when one type of tissue slides across another, thus stretching or pulling apart the cellular structure. Since the tissues of the brain itself are of different densities, shear strains also can take place within the brain or brain stem as a result of rotatory movement. As with linear motion the injurious forces will vary with the rate of acceleration or deceleration.

2. Injury of the Brain by Distortion of the Skull. This type of injury is less frequent in civilian prac-

tice than those already discussed. However, certain traumas in producing general or local distortion of the skull may cause general or local crushing, pulping or bruising of the brain.

3. Brain Injury from Compression of the Thorax. Injuries of the brain, especially in the form of petechial hemorrhages, have been reported following blast or direct compression of the thorax.

4. Injury of the Brain Due to Penetrating Objects or Missiles. This aspect of trauma will be discussed under surgical lesions of the skull and brain.

2

NONSURGICAL CASES OF HEAD INJURY

In civilian practice over 97 per cent of all cases, and about 90 per cent of severe cases, of head injury suffer from a nonsurgical (nonoperable) craniocerebral injury, if open head wounds are excluded.* A high percentage of these nonsurgical cases have an injury of the brain, reversible or otherwise, but the treatment is conservative.

NONSURGICAL LESIONS OF THE BRAIN

Concussion. The fundamental basis of concussion is still unknown. When the term concussion is used clinically it usually implies an immediate traumatic loss of consciousness lasting for a variable period and unaccompanied by evidence of structural damage to the brain. There is a wide difference of opinion, however, as to whether prolonged unconsciousness can occur in the absence of demonstrable organic brain injury.[2, 20, 37, 53, 103, 109]

Denny-Brown and Russell [20] define experimental concussion as the occurrence of an immediate traumatic paralysis of reflex function, which occurs in the

* See Chapter 3 for more detailed statistics.

absence of visible lesions in the nervous system. They regard concussion as a generalized reversible "molecular reaction" induced by physical stress. Subconcussive blows, on the other hand, depress but do not abolish these reflex functions. They are of the opinion that pure concussion can account for a prolonged period of cerebral disturbance in man corresponding to the period of coma, semicoma and confusion which commonly follows a severe head injury. Such an injury they think may be associated with contusion and petechial hemorrhages in the brain stem, but these lesions are not responsible for the basic generalized cerebral disturbance of concussion.

Denny-Brown and Russell have shown that concussion can be produced when an animal's head is subjected to a sufficiently high rate of change of velocity. The change of velocity may be positive or negative and accordingly results in what they term either an acceleration or a deceleration concussion. Sudden acceleration sets up a complicated series of strains and distortions within the brain stem and cervical cord and it is these forces that are responsible for concussion as well as for hemorrhagic lesions when they occur. These hemorrhagic lesions are considered to occur immediately and are believed to be the result of direct injury and not due to prestasis, stasis and diapedesis.

Williams and Denny-Brown [108] have reported the electro-encephalographic changes in experimental concussion. They found an immediate diminution of electrical activity from the whole cerebral hemispheres associated with concussion, followed by the appearance of slow waves. Reflex activity returned while the electrical activity was still diminished. They con-

cluded that concussion is the direct result of mechanical violence to cerebral cells.

Another cause of concussion as demonstrated by Scott,[93] and Gurdjian and Webster [36] is that due to sudden brain compression. This, according to Denny-Brown and Russell is much less common than that resulting from acceleration injury. Compression concussion may occur with severe penetrating wounds, certain depressed fractures and other types of injury that are accompanied by a sudden rise in intracranial pressure.

Walker *et al.*[103] have provided evidence that experimental concussion is the result of intense excitation of the central nervous system at the moment of the blow to the head, which is manifested by a marked electrical discharge and a temporary breakdown of the polarized cell membranes of many neurones in the brain.

A review of many of the opinions held by investigators regarding the nature and cause of concussion may be found in the article by Denny-Brown and Russell.[20]

Contusion. A local contusion of the brain is an area of traumatic bruising in which there are varying degrees of swelling, perivascular hemorrhage, disruption of cellular structure and even rupture of blood vessels. The latter may give rise to an intracerebral hematoma (discussed under surgical lesions) (Fig. 1).

Laceration. A laceration of the brain is an actual tearing of the neural and other tissues. There is no sharp dividing line between contusion and laceration and both lesions are commonly found, for instance, at the site of the blow, at the area of contrecoup, on the under surface of the frontal lobe, or at the tem-