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A REVIEW OF CASES OF INJURY TO THE VERTEBRAE OCCURRING IN THE ROYAL AIR FORCE

BY

Wing Commander PHILIP A. HALL, M.A., M.D., M.Ch.
Consultant in Surgery to the Royal Air Force

AND

Flight Lieutenant GEORGE H. MORLEY, F.R.C.S.
Royal Air Force

The medical branch of the Royal Air Force has occasion to treat a large number of accident casualties in the course of routine duties, but it must not be assumed that these are usually associated with the practice of aviation. An aircraft accident may on occasion be appallingly destructive in its effects, yet it is surprising how much the human frame can tolerate and how often the pilot and occupants are relatively uninjured when the machine may be totally wrecked. Conversely, slight accidents may have tragic results through sheer misfortune. The cases that require prolonged treatment and study are those which are severely injured and yet survive the immediate effects of the crash. It is a limited class.

On the other hand, the Air Force consists of a rapidly increasing number of healthy individuals who are chiefly below 30 years of age, who are encouraged to lead an active life, and for whom there are opportunities to indulge in most forms of sport. In a study of vertebral injuries we find that the majority of the cases which come under the care of the Air Force surgeons are the result of everyday life, as opposed to flying.

It is very difficult to draw any conclusions as to whether there are essential underlying differences between the types of injuries received in flying accidents and those which occur as the result of other types of accidents. One interesting fact revealed itself in our survey of these cases—the high proportion of completely satisfactory results in pilots and airmen, so that they have eventually returned to full Air Force duty.

In the case of the flying personnel there is a special significance when it is appreciated that in the United Kingdom pilots of Service and commercial aircraft require to be passed medically fit by the Central Medical Establishment of the Air Ministry. Only after an exhaustive medical examination are pilots graded as physically fit for full flying duties, for there is a definite duty to safeguard the occupants of aircraft and the general public by eliminating the unfit pilot. The surgeon's concern is chiefly that of the function of the limbs and, with the neurologist, to

ensure that movements are co-ordinated. Consideration has to be given to the necessity that function shall be correct under the stresses imposed by flying, such as those due to increases of "gravity" and height and to the sitting for long periods in relatively cramped positions. A high level of efficiency has to be maintained, and it is significant that of the very small number of cases we are able to quote the majority were ultimately passed fit for flying duties. Little more than a decade ago such cases would probably have been condemned to be cripples for life. Now, despite the fact that we cannot claim to be dogmatic on such slender evidence, it would appear that they have a reasonable opportunity of achieving this high standard of physical fitness.

Analysis of Case Records*

A search was made through the records of the last five years for cases which had received treatment for injuries to the vertebral column. We are able to trace fifty-seven such cases, but are unable to state that these represent all those which have occurred during this period, although none has been omitted to our knowledge. Of this total nine were the result of flying accidents, and the remainder were the result of non-flying accidents such as might occur in ordinary civil life. Of the flying personnel categorized as pilots, sixteen were injured; but of these only seven received their injuries in accidents to aircraft. Injuries received in aircraft accidents in all cases involved fractures of the bodies of the vertebrae, whereas other accidents gave rise to various types of injuries.

Flying Accidents

There follow a record (Table I) and a summary of flying accidents to pilots and non-pilots:

* In the tables and case summaries the following abbreviations have been observed: A1—Fit for full flying duties. A2—Fit for limited flying duties. A3—Fit as combatant passenger in aircraft. A4—Fit as non-combatant passengers in aircraft. B—Fit for ground duties. t—Temporarily unfit. p—Permanently unfit. h—Fit for duties at home only.

TABLE I.—*Flying Accidents*

Case No.	Age	Occupation at Time of Accident	Site of Vertebral Injury	Type of Vertebral Injury	Injury to Cord, Paralysis, etc.	Treatment by Hyper-extension	Medical Category on Discharge from Hospital	Time after Accident (Months)	Recent Medical Category	Time after Accident (Years)	Remarks
1	18	Pilot	C. 7	Fr. dis.	++	Yes	Ap Bp	7	—	—	Physiological transection of cord. Died
2	23	"	L. 2	Comp. fr.	No	"	A1h Bh	6	A1B	6	Ambulant after fourteen days
3	22	Air gunner	L. 2	" "	"	"	A1B	9	A1B	2½	Plaster retained for six months
4	24	Pilot	D. 4	Slight comp. fr.	"	No	A2h Bh 10,000 ft.	7	A1B	4	No paralysis. Some muscular wasting and "sciatica"
5	23	"	D. 3, 4, and 5	Comp. fr.	"	Yes	A4h Bh	5	A1h, Bh	2	Ambulant after four days. Started limited flying after twelve months
6	30	Passenger	D. 11 and 12	" "	"	"	Fit for duty	6	—	—	Slight muscular weakness noted in early stages (non-pilot)
7	23	"	L. 5 and ala of sacrum	—	"	"	" "	4	—	—	Fracture of body of L. 5 and ala of sacrum. Plaster worn for six weeks
8	—	"	L. 2, 3, and 4	Comp. fr.	"	?	Invalided	—	—	—	Resulted in gross deformity
9	—	Pilot	L. 1	" "	"	?	A1B	—	—	—	

Summary of Flying Accidents.—Fractures of bodies of vertebrae, 9 (A1B, 4; A1h Bh, 1; fit for duty, 2; died, 1; invalided, 1). There were no other vertebral injuries.

Non-flying Accidents (Pilots)

Details of the non-flying accidents occurring to pilots are given in Table II; these are followed by a summary of the cases.

processes of C. 7 and D. 1, with irreparable injury to the brachial plexus. He subsequently had to undergo amputation of the flail limb and was invalided from the Service. A third had a dislocated C. 5 as the result of a motor accident, with complete paralysis of the lower limbs. The dislocation was reduced by a pull of 60 lb. on the head two days after the injury; but there was no evidence of recovery six months later, and he was invalided. The fourth fractured the lamina of C. 3 as

TABLE II.—*Non-flying Accidents (Pilots)*

Case No.	Age	Type of Accident	Site of Vertebral Injury	Type of Vertebral Injury	Injury to Cord, Paralysis, etc.	Treatment by Hyper-extension	Medical Category on Discharge from Hospital	Time after Accident (Months)	Recent Medical Category	Time after Accident (Years)	Remarks
1	24	Hunting	C. 5	Dislocation	No	Yes	A4h Bh	14	A1B	2	Hyperextension, etc., failed to reduce. Spinal fusion performed. A1B seven months later
2	20	Car	L. 1 and 2	Comp. fr.	"	"	A1B	17			
3	31	Fall from window	D. 8	" "	"	"	A4h Bh	6	A1B	2	
4	23	Car	L. 2	" "	"	"	A1B	20			Anterior portion of body of L. 2 fractured. Recumbent for two months. Reduction incomplete. Ambulant with support two months after accident
5	27	Fell 13 ft.	L. 2	" "	"	"	A1B	7	—	—	
6	—	Kick at football	L. 2 and 3	Trans. proc.	"	No	A1B	3	—	—	
7	24	Car	L. 1	Comp. fr.	Yes	Yes	Invalided	15	—	—	Slight displacement. Hyperextension performed four days after accident. Improved
8	—	Fall	L. 1, 2, and 3	Trans. proc.	No	No	A1B	after 5 months			
9	—	Cycle fall	L. 1	" "	"	"	?	1	—	—	Disposal uncertain. Thirty-six days in hospital

Summary of Non-flying Accidents (Pilots).—Body of vertebra, 5 (A1B, 4; invalided, 1). Dislocation, 1 (A1B, 1). Other injuries to vertebrae, 3 (A1B, 2; uncertain, 1).

Non-flying Accidents (Non-pilots)

It is not proposed to go in any great detail into the injuries arising out of the pursuit of a non-flying occupation affecting the personnel of the Service who are not categorized as to their fitness for flying duties, as these show no points of interest which differ from such cases occurring in civil life.

Summary of Non-flying Accidents (Non-Pilots).—Compression fractures, 13 (fit for duty, 4; light duty, 5; sick leave, 2; invalided, 1; untraced, 1). Fractures of transverse processes, 16 (fit for duty, 15; invalided, 1). Other injuries, 10 (fit for duty, 8; invalided, 2).

Of the patients who were ultimately invalided from the Service, one with a compression fracture of L. 1 subsequently developed nephritis, for which he was invalided. Another fell heavily on the back of his head and neck as the result of a motor accident, fracturing the transverse

the result of vaulting. He was placed in a plaster in full extension, but six weeks afterwards he had an epileptiform convulsion, when radiological examination revealed a forward subluxation of the vertebrae. The plaster was renewed, but he later became excited, and after a period of mental observation was invalided from the Service nine months from the time of his accident. It is doubtful how much of his symptomatology was due to the mechanical injury of the vertebrae, as no paralysis was noted.

Method of Treatment

It is possible only to generalize on the subject of treatment, as these cases have arisen throughout the Service and have been treated in various stages by our colleagues, while some received their initial treatment at the different civilian hospitals to which they were admitted following their accidents. We have attended some of these cases, and one of us (P. A. H.) has had the opportunity of examining most of them and of taking charge of many. Full primary radiological investigation of all cases with the least suspicion of spinal injury after an accident is

essential, as vertebral injuries are at times discovered only by following this practice.

As a general rule the teachings of Watson Jones and Böhler have been applied in principle—that is, early reduction by hyperextension and fixation in plaster-of-Paris. We ourselves practise early ambulation when possible,

Reduction in a Case of Bilateral Cervical Dislocation

A sergeant instructor in physical training, aged 32, was demonstrating a somersault when he slipped and fell on the back of his head. He was found to have sustained a bilateral dislocation of the articular processes between C. 4 and 5 (Fig. 1). He had an immediate partial motor paralysis of the

FIG. 1.—Bilateral dislocation of articular processes of fourth and fifth cervical vertebrae. Radiograph taken on admission.

FIG. 2.—Same case after unsuccessful attempts at reduction. Displacement persists.

FIG. 3.—The case after reduction.

FIG. 4.—Radiograph taken eighteen months after reduction.

and it would appear that our colleagues in the Air Force have a similar outlook. Open operative procedure has not been recorded except in the one case of cervical dislocation quoted above, when delayed spinal fusion was successful. Laminectomy has not been performed in the series examined. One case of bilateral dislocation of a cervical vertebra which proved most resistant to reduction deserves a detailed description.

upper and lower limbs, which was followed within two days by complete motor and sensory paralysis below the level of C. 5. Traction was attempted, followed by a weight extension of 16 lb. for six days. This failed to effect reduction or clinical improvement (Fig. 2). With general anaesthesia (gas-and-oxygen) mechanical traction was applied by means of a double loop of wool skein placed under the chin and occiput, connected to a system of pulleys with the incorporation of a dynamometer. Countertraction was obtained by the shoulder

pieces on the operating table and straps passed around the body, both the table and the pulleys being attached to fixed points in the structure of the operating theatre. During the application of stress observation was continued by means of a Victor portable x-ray set combined with the use of a daylight fluoroscope by an assistant.

Full distraction was not obtained until the dynamometer, which was accurate, registered a pull of 160 lb., when the articular facets separated. The antero-posterior displacement was then corrected by a strong forward pull applied through a loop of unyielding calico bandage passed behind the lowest part of the neck, together with a forcible backward thrust applied to the transverse processes of the vertebrae above the injury. As soon as the displacement appeared to be corrected, as judged by the fluoroscope, the traction was released and the vertebrae adopted a correct position (Fig. 3). Plaster-of-Paris was applied immediately in order to maintain hyperextension. Later lumbar puncture was performed, and Queckenstedt's test gave a satisfactory response to compression of the jugular veins and to respiration.

The subsequent history showed recovery of minute movements of the toes in three months, followed very slowly by a steady return of power and sensation until, eighteen months after his accident, full function was restored. He returned to duty, and two years later he continues to be fit. The latest radiograph, taken six months ago, shows only slight anterior displacement with a little absorption of the lip of the body of the lower vertebra (Fig. 4).

Commentary

Current literature reveals wide acceptance of the principles of treatment of crush fracture of the body of a vertebra by early reduction by means of hyperextension and adequate fixation. Usually this reduction is effected by the technique of either Watson Jones or Davis (Watson Jones, 1931; Davis, 1929). Williamson (1938) considers that concomitant fracture of a neighbouring articular process may render these methods dangerous, and he prefers a slower reduction on a hyperextension frame in these cases. Watson Jones (1934) does not appear to consider that this danger exists. On the other hand, damage may be done to the cord by attempting hyperextension of the spine when a dislocation and displacement of the articular processes accompanies a fracture of the body. Here a displaced and locked articular process may act as fulcrum for gross hyperextension and undue traction upon the cord. In these cases reduction of the dislocation, usually by open operation, must precede hyperextension. Excision of the articular process may be necessary (Watson Jones, 1938; Rogers, 1938).

The complication of paralysis is no contraindication to hyperextension, but is rather a strong indication for early reduction. It is held that much of the initial paralysis is due to spinal concussion and is therefore transient, although recovery may be delayed. Pressure on the cord caused by malposition of the vertebrae may result in permanent damage through local anaemia. At first it is almost impossible to differentiate between such a paralysis and that due to mechanical crushing of the cord, which is irreparable. Hauser (1935) reports three cases of spastic paralysis which were improved by hyperextension even after the lapse of time. One case was four months, another three years, and the third six years after the injury had been received. In the latter two cases a fusion operation was performed after the improvement which followed reduction.

Effective immobilization in a plaster jacket is usual. The patient must become accustomed to the jacket rather than have its function destroyed by ill-advised, albeit sympathetic, removal of little bits here and there until the essential extent of the plaster is lost. Early ambula-

tion, subject to the perfect efficiency of the plaster, is an excellent practice where possible. Not only is the tone of the spinal musculature improved, but the patient does not develop the rapidly acquired impression that he is and will remain a cripple. The plaster must be retained until consolidation is complete—three months for slight cases to six months or more for the more severe.

Laminectomy has practically disappeared from the treatment of these cases, although some authors describe various and at times complicated indications for its performance. The impression given by present literature is that it is seldom necessary, and "it is not likely that any improvement in the patient's condition will result" (Wakeley, 1936).

The mechanism of these injuries has been adequately explained in, for example, a paper by Lambrinudi (1936). We find it difficult to agree that fractures of transverse processes are essentially traction fractures. While we agree that these may occur possibly, as Koudienko (1936) suggests, by sudden muscular action in a fully rotated spine, we find that of sixteen cases of this injury in the series examined in this paper eleven gave a history of a definite blow over the affected site. The other five had indefinite histories which might have indicated either direct or indirect trauma.

Methods of reduction of dislocations of the cervical vertebrae are a trifle diverse. Skeletal traction is advocated by Crutchfield (1936), Hoen (1936), and Barton (1938). The advantages and disadvantages in the application of skeletal traction to the skull are fairly obvious. Jefferson (1933) advocated postural traction, with fixation of the head in extension by means of a sling under the chin. We would refer to the method of controlled and observed powerful traction practised by one of us (P. A. H.) and described earlier in this paper, with the comment that such a method gives the operator an assurance which he would not otherwise enjoy when dealing with such a vital area.

Summary

Fifty-seven cases of injury to the vertebral column have been reviewed, of which nine were the result of flying accidents and sixteen affected flying personnel.

The majority of the flying personnel affected returned to full flying duties.

A method of controlled traction under visual observation is described for the reduction of a cervical dislocation.

A few comments are made upon current literature.

We wish to acknowledge and stress the fact, to which we have previously referred, that many of our colleagues have treated a proportion of these cases, while others have been transferred from civil hospitals. References to the current literature have been provided and papers for study lent by the librarian of the Royal Society of Medicine, to whom we would express our gratitude.

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CONVULSIONS OCCURRING UNDER VINESTHENE ANAESTHESIA

BY

C. J. MASSEY DAWKINS, M.A., M.D., D.A.

Honorary Anaesthetist, University College Hospital

Convulsions occurring under vinesthene anaesthesia have not, so far, been recorded in this country, although, according to a personal communication from Professor Rovenstine of New York University, they have been observed in America. During the last two years I have given vinesthene on 2,406 occasions, and there have been nine cases of convulsions, none of them fatal. These cases may be divided into two groups: 196 in-patient operations with four convulsions and 2,210 dental out-patient extractions with five convulsions—incidences of 1 in 49 and 1 in 442 respectively. The nature of the convulsions in the in-patient group was, however, quite different from that of the out-patient group.

Convulsions in the In-patient Group

The convulsions which occurred in the in-patients came on towards the close of the operation, and were very similar to those met with under deep ether anaesthesia, with the exception that each case had an evipan induction. A search of the literature of ether convulsions has not revealed a single case coming after premedication with a barbiturate drug. The intravenous injection of a barbiturate will immediately abort a case of ether convulsions, so an entirely different factor must be present in vinesthene convulsions, as these come on after a barbiturate has been given. Detailed case records follow.

Case 1.—Acute appendicitis in a nurse aged 22. Evipan induction was followed by nitrous oxide-oxygen-vinesthene with carbon dioxide absorption, using Connell's machine. The anaesthesia was normal until sewing up of the peritoneum, then respiration became irregular and convulsions started in the throat muscles, rapidly spreading all over the body and becoming most violent in character. Respiration ceased for two minutes and the pulse failed for a few seconds. Respiration then restarted with inspiratory stridor and gradually returned to normal, the convulsions gradually ceasing. Treatment consisted in stopping the anaesthetic and raising the head. The rectal temperature was 99° and the theatre temperature 75°. Recovery was uneventful. There was no previous history of fits. The soda lime was tested and found not to have lost its absorptive power: it was thought that the condition might have been due to excess carbon dioxide.

Case 2.—Resection of colon in a man aged 72. The anaesthetic sequence was the same as in the first case. Convulsions started while the peritoneum was being sewn up. There was slight cyanosis but no respiratory arrest; the head was raised without effect, but convulsions ceased after five minutes, only to recur later when anaesthesia became too light. The rectal temperature was 99° and the theatre temperature 74°, and a thunderstorm was in progress. Recovery was uneventful. There was no history of fits. 55 c.cm. of vinesthene was used before the convulsions started.

Case 3.—A plastic operation to a kidney in a man aged 24. Vinesthene was used as he had bronchiectasis. The anaesthetic sequence was as in the first case. Convulsions started after twenty minutes' anaesthesia; the head was raised without effect, and 2 c.cm. of evipan was then given intravenously, with immediate cessation of convulsions. Later, as the respiration was shallow, 3 c.cm. of coramine was given. The rectal temperature was 99.6° and the theatre temperature 78°; the weather was dull and oppressive. Recovery was uneventful.

Impaired Memory after Convulsions.—Nine out of sixteen patients (mostly schizophrenics) who recovered or improved after treatment by induced convulsions complained of impaired memory; and in eight there was impairment of intellect. Caution is advised in using this treatment in those whose work depends on memory and intellect.—Disturbance of Memory after Convulsion Treatment. G. Tooth and J. M. Blackburn.—*Lancet*, July 1, 1939, **2**, 17.