

Frontal Lobe Function: Mr. Phineas Gage's Famous Injury

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The next article in our series is a case report written in 1848 by John M. Harlow, M.D.,¹ describing his care of Mr. Phineas Gage, who suffered an extreme injury to the frontal cortex. Mr. Gage was employed as a railroad worker in Vermont and fell victim to a freak accident that involved a long metal rod called a tamping iron. This rod was used to pack sand over an explosive charge, which was used to excavate rock for the building of railroad lines. In this instance the charge exploded unexpectedly and propelled the 3-foot-long rod through Mr. Gage's head. The 13-pound rod entered the left cheek and exited the midline of the skull anterior to the bregma, resulting in severe injury to his left and, in all probability,² his right prefrontal cortex. The Gage case, one of the most famous and influential in neuropsychiatry, played a crucial role in the discovery of behavioral syndromes resulting from frontal lobe dysfunction. Readers interested in detailed accounts of the case and its historical context can find excellent reviews by MacMillan³ and Barker.⁴

The case report was initially met with disbelief because it was thought to be impossible for a human to survive a brain injury of such magnitude. Beyond the astonishing fact of Mr. Gage's survival was the description of his ability to walk immediately after the event, communicate sensibly, and remain lucid though most of the period following the injury. This fact attracted the attention of P. T. Barnum, who employed Mr. Gage for a short period following his recovery. Dr. Henry J. Bigelow, a prominent professor of surgery at Harvard Medical School, examined Mr. Gage after Harlow's report and failed to note the changes in Gage's behavior. He proclaimed that Gage had no demonstrable sequelae of the injury. Dr. Bigelow and others used the Gage case as a persuasive argument against the field of phrenology, which was the only prominent discipline at the time that considered the possibility of localization of brain function.

Yet, as the reader will note, there are several suggestions in the original report that Mr. Gage's behavior had changed. Dr. Harlow promised to report the mental manifestations of the injury in a subsequent communi-

cation. He did not produce this report until 20 years later, when he described a pervasive change in personality and character in the *Journal of the Massachusetts Medical Society*, a periodical with very limited circulation.⁵ In this report, Harlow described the following:

His contractors, who regarded him as the most efficient and capable foreman in their employ previous to his injury, considered the change in his mind so marked that they could not give him his place again. He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at times pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operation, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. In this regard, his mind was radically changed, so decidedly that his friends and acquaintances said he was "no longer Gage."

Dr. David Ferrier, who was an early champion for the theory of cerebral localization, discovered Harlow's second report and used it as the highlight of his famous 1878 Goulstonian lectures,⁶ which described in detail the focal mapping of the cerebral function. The frontal lobes were considered to be involved in higher executive function. Dr. Ferrier cited the Gage case as a primary example of how frontal lobe injury can result in changes of personality that are not demonstrable by sensory and motor exam. The Gage case is now one of the most frequently cited articles from nineteenth-century medical literature.

Phineas Gage died in San Francisco, apparently from complications of seizures, 12 years after his injury. Dr. Harlow obtained consent from Mr. Gage's family to obtain the skull and tamping iron, which are now in the collection of the Warren Anatomic Museum at Harvard University.

References

1. Harlow JM: Passage of an iron rod through the head. *Boston Medical and Surgical Journal* 1848; 39:389-393
2. Damasio H, Grabowski T, Frank R, et al: The return of Phineas Gage: clues about the brain from the skull of a famous patient. *Science* 1994; 264:1102-1105

"Passage of an Iron Rod Through the Head," by J. M. Harlow, originally appeared as a letter to the editor of the *Boston Medical and Surgical Journal* (vol. 39, no. 20, December 13, 1848, pp. 389-393).

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3. MacMillan MB: A wonderful journey through skull and brains: the travels of Mr. Gage's tamping iron. *Brain Cogn* 1986; 5:67-107
4. Barker FG: Phineas among the phrenologists: the American crow-bar case and nineteenth-century theories of cerebral localization. *J Neurosurg* 1995; 82:672-682
5. Harlow JM: Recovery from the passage of an iron bar through the head. *Publications of the Massachusetts Medical Society* 1868; 2:327-347
6. Ferrier D: The Goulstonian lectures on the localization of cerebral diseases. *British Medical Journal* 1878; 1:443-447

Passage of an Iron Rod Through the Head

John M. Harlow, M.D.

To the Editor of the *Boston Medical and Surgical Journal*.

DEAR SIR,—Having been interested in the reading of the cases of "Injuries of the Head," reported in your *Journal* by Professor Shipman, of Cortlandville, N.Y., I am induced to offer you the notes of a very severe, singular, and, so far as the result is taken into account, hitherto unparalleled case, of that class of injuries, which has recently fallen under my own care. The accident happened in this town, upon the line of the Rutland and Burlington Rail Road, on the 13th of Sept. last, at 4½ o'clock, P.M. The subject of it is Phineas P. Gage, a foreman, engaged in building the road, 25 years of age, of middle stature, vigorous physical organization, temperate habits, and possessed of considerable energy of character.

It appears from his own account, and that of the bystanders, that he was engaged in charging a hole, preparatory to blasting. He had turned in the powder, and was in the act of tamping it slightly before pouring on the sand. He had struck the powder, and while about to strike it again, turned his head to look after his men (who were working within a few feet of him), when the tamping iron came in contact with the rock, and the powder exploded, driving the iron against the left side of the face, immediately anterior to the angle of the inferior maxillary bone. Taking a direction upward and backward toward the median line, it penetrated the integuments, the masseter and temporal muscles, passed under the zygomatic arch, and (probably) fracturing the temporal portion of the sphenoid bone, and the floor of the orbit of the left eye, entered the cranium, passing through the anterior left lobe of the cerebrum, and made its exit in the median line, at the junction of the coronal and sagittal sutures, lacerating the longitudinal sinus, fracturing the parietal and frontal bones extensively,

breaking up considerable portions of brain, and protruding the globe of the left eye from its socket, by nearly one half its diameter. The tamping iron is round, and rendered comparatively smooth by use. It is pointed at the end which entered first, and is three feet, seven inches in length, one and one quarter inch in diameter, and weighs 13¼ pounds. I am informed that the patient was thrown upon his back, and gave a few convulsive motions of the extremities, but spoke in a few minutes. His men (with whom he was a great favorite) took him in their arms and carried him to the road, only a few rods distant, and sat him into an ox cart, in which he rode, sitting erect, full three quarters of a mile, to the hotel of Mr. Joseph Adams, in this village. He got out of the cart himself, and with a little assistance walked up a long flight of stairs, into the hall, where he was dressed.

Being absent, I did not arrive at the scene of the accident until near 6 o'clock, P.M. You will excuse me for remarking here, that the picture presented was, to one unaccustomed to military surgery, truly terrific; but the patient bore his sufferings with the most heroic firmness. He recognized me at once, and said he hoped he was not much hurt. He seemed to be perfectly conscious, but was getting exhausted from the hemorrhage, which was very profuse both externally and internally, the blood finding its way into the stomach, which rejected it as often as every 15 or 20 minutes. Pulse 60, and regular. His person, and the bed on which he was laid, were literally one gore of blood. Assisted by my friend, Dr. Williams, of Proctorsville, who was first called to the patient, we proceeded to dress the wounds. From their appearance, the fragments of bone being uplifted and the brain protruding, it was evident that the fracture was occasioned by some force acting from below upward. The scalp was shaven, the coagula removed, together with three small triangular pieces of the cranium, and in searching to ascertain if there were other foreign bodies there, I passed in the index finger its whole length, without the least resistance, in the direction of the sound in the cheek, which received the other finger in like manner. A portion of the anterior superior angle of each parietal bone, and a semi-circular piece of the frontal bone, were fractured, leaving a circular opening of about 3½ inches in diameter. This examination, and the appearance of the iron which was found some rods distant, smeared with brain, together with the testimony of the workmen, and of the patient himself, who was still sufficiently conscious to say that "the iron struck his head and passed through," was considered at the time sufficiently conclusive to show not only the nature of the accident, but the manner in which it occurred.

I have been asked why I did not pass a probe through

the entire extent of the wound at the time. I think no surgeon of discretion would have upheld me in the trial of such a foolhardy experiment, in the risk of disturbing lacerated vessels, from which the hemorrhage was near being staunched, and thereby rupturing the attenuated thread, by which the sufferer still held to life. You will excuse me for being thus particular, inasmuch as I am aware that the nature of the injury has been seriously questioned by many medical men for whom I entertain a very high respect.

The spiculae of bone having been taken away, a portion of the brain, which hung by a pedicle, was removed, the larger pieces of bone replaced, the lacerated scalp was brought together as nearly as possible, and retained by adhesive straps, excepting at the posterior angle, and over this a simple dressing—compress, night-cap and roller. The wound in the face was left patulous, covered only by a simple dressing. The hands and fore arms were both deeply burned nearly to the elbows, which were dressed, and the patient was left with the head elevated, and the attendants requested to keep him in that position.

10, P.M., same evening.—The dressings are saturated with blood, but the hemorrhage appears to be abating. Has vomited twice only since being dressed. Sensorial powers remain as yet unimpaired. Says he does not wish to see his friends, as he shall be at work in a day or two. Tells where they live, their names, &c. Pulse 65; constant agitation of the lower extremities.

14th, 7, A.M.—Has slept some; appears to be in pain; speaks with difficulty; tumefaction of face considerable, and increasing; pulse 70; knows his friends, and is rational. Asks who is foreman in his pit. Hemorrhage internally continues slightly. Has not vomited since 12, M.

15th, 9, A.M.—Has slept well half the night. Sees objects indistinctly with the left eye, when the lids are separated. Hemorrhage has ceased. Pulse 75.

8, P.M., same day.—Restless and delirious; talks much, but disconnected and incoherent. Pulse 84, and full. Prescribed *vin. colchicum*, [$\frac{1}{2}$ dram (~2 ml)] every six hours, until it purges him. Removed the night-cap.

16th, 8, A.M.—Patient appears more quiet. Pulse 70. Dressed the wounds, which in the head have a foetid sero-purulent discharge, with particles of brain intermingled. No discharge from bowels. Ordered sulph. magnesia, [1 ounce (~31 g)], repeated every four hours until it operates. Iced water to the head and eye. A fungus appears at the external canthus of the left eye. Says "the left side of his head is banked up."

17th, 8, A.M.—Pulse 84. Purged freely. Rational, and knows his friends. Discharge from the brain profuse, very foetid and sanious. Wound in face healing.

18th, 9, A.M.—Slept well all night, and lies upon his

right side. Pulse 72; tongue red and dry; breath foetid. Removed the dressings, and passed a probe to the base of the cranium, without giving pain. Ordered a cathartic, which operated freely. Cold to the head. Patient says he shall recover. He is delirious, with lucid intervals.

19th, 8, P.M.—Has been very restless during the day; skin hot and dry; tongue red; excessive thirst; delirious, talking incoherently with himself, and directing his men.

20th and 21st.—Has remained much the same.

22d, 8, A.M.—Patient has had a very restless night. Throws his hand and feet about, and tries to get out of bed. Head hot. Says "he shall not live long so." Ordered a cathartic of calomel and rhubarb, to be followed by castor oil, if it does not operate in six hours.

4, P.M., same day—Purged freely twice, and inclines to sleep.

23d.—Rested well most of the night, and appears stronger and more rational. Pulse 80. Shaved the scalp a second time, and brought the edges of the wound in position, the previous edges having sloughed away. Discharge less in quantity and less foetid. Loss of vision of left eye.

From this time until the 3d of October, he lay in a semi-comatose state, seldom speaking unless spoken to, and then answering only in monosyllables. During this period, fungi started from the brain, and increased rapidly from the orbit. To these was applied nitrate of silver cryst., and cold to the head generally. The dressings were renewed three times in every twenty-four hours; and in addition to this, laxatives, combined with an occasional dose of calomel, constituted the treatment. The pulse varied from 70 to 96—generally very soft. During this time an abscess formed under the frontalis muscle, which was opened on the 27th, and has been very difficult to heal. Discharged nearly [8 ounces (~240 ml)] at the time it was punctured.

Oct. 5th and 6th.—Patient improving. Discharge from the wound a sinus, laudable pus. Calls for his pants and wishes to get out of bed, though he is unable to raise his head from the pillow.

7th.—Has succeeded in raising himself up, and took one step to his chair, and sat about five minutes.

11th.—Pulse 72. Intellectual faculties brightening. When I asked him how long since he was injured, he replied, "four weeks this afternoon, at 4½ o'clock." Relates the manner in which it occurred, and how he came to the house. He keeps the day of the week and time of day, in his mind. Says he knows more than half of those who inquire after him. Does not estimate size or money accurately, though he has memory as perfect as ever. He would not take \$1000 for a few pebbles which he took from an ancient river bed where he was at work. The

fungus is giving way under the use of the crys. nitrate of silver. During all of this time there has been a discharge of pus into the fauces, a part of which passed into the stomach, the remainder being ejected from the mouth.

20th.—Improving. Gets out and into bed with but little assistance. Sits up thirty minutes twice in twenty-four hours. Is very childish; wishes to go home to Lebanon, N.H. The wound in the scalp is healing rapidly.

Nov. 8th.—Improving in every particular, and sits up most of the time during the day. Appetite good, though he is still kept upon a low diet. Pulse 65. Sleeps well, and says he has no pain in the head. Food digests easily, bowels regular, and nutrition is going on well. The sinus under the frontalis muscle has nearly healed. He walks up and down stairs, and about the house, into the piazza, and I am informed this evening that he has been in the street to-day.—I leave him for a week, with strict injunctions to avoid excitement and exposure.

15th.—I learn, on inquiry, that Gage has been in the street every day except Sunday, during my absence. His desire to be out and to go home to Lebanon has been uncontrollable by his friends, and he has been making arrangements to that effect. Yesterday he walked half a mile, and purchased some small articles at the store. The atmosphere was cold and damp, the ground wet, and he went without an overcoat, and with thin boots. He got wet feet and a chill. I find him in bed, depressed and very irritable. Hot and dry skin; thirst; tongue coated; pulse 110; lancinating pain in left side of head and face; rigors, and bowels constipated. Ordered cold to head and face, and a black dose to be repeated in six hours, if it does not operate. He has had spiculae of bone pass into the fauces, which he expelled from the mouth within a few days.

16th, A.M.—No better. Cathartic has operated freely.

Pulse 120; skin hot and dry; thirst and pain remain the same. Has been very restless during the night. Venesection [16 ounces (~475 ml)]. Ordered calomel, [10 grains (~650 mg)], and ipecac, [2 grains (~130 mg)], followed in four hours by castor oil.

8, P.M., same day.—Purged freely; pulse less frequent; pain in head moderated; skin moist. R. Antim. et potassa tart., [3 grains (~195 mg)]; syr. simplex, [6 ounces (~180 ml)]. Dose a dessert spoonful every four hours.

17th.—Improving. Expresses himself as “feeling better in every respect;” has no pain in the head.

18th.—Is walking about house again; says he feels no pain in the head, and appears to be in a way of recovering if he can be controlled.

At this date I shall leave the case at present. The result, and a few remarks of a practical nature, together with the mental manifestations of the patient, I reserve for a future communication. I think the case presents one fact of great interest to the practical surgeon, and, taken as a whole, is exceedingly interesting to the enlightened physiologist and intellectual philosopher. In my effort to be brief, which I fear you will think an utter failure, I have omitted much in my notes that might interest some readers. Allow me to say here, that I have seen a communication in “The Reflector and Watchman,” stating that “there is a piece of bone loose in the top of his head, as large as a dollar, which will have to be removed, should he live.” The fractured portions of bone, excepting those which were removed at the first dressing, have united firmly, and the above remark was made unadvisedly. Should you think these notes of sufficient importance to deserve a place in your Journal, they are at your service.

Yours, very respectfully,

J. M. Harlow.

Cavendish, Vt., Nov. 27, 1848.