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“No Clinical Puzzles More Interesting”: Harvey Cushing and Spinal Trauma, The Johns Hopkins Hospital 1896-1912

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Abstract

Although Harvey Cushing played a central role in the establishment of neurosurgery in the United States, his work on the spine remains largely unknown. This article is not only the first time that Cushing's spinal cases while he was at Johns Hopkins have been reported, but also the first time his management of spinal trauma has been described. We report on 12 patients that Cushing treated from 1898 to 1911 who have never been reported before, including blunt and penetrating injuries, complete and incomplete spinal cord lesions, and both immediate and delayed presentations. Cushing performed laminectomies within 24 hours on patients with immediate presentations—both complete and incomplete spinal cord lesions. Among those with delayed presentations, Cushing did laminectomies on patients with incomplete spinal cord injuries. By the end of his tenure at Hopkins, Cushing advocated nonoperative treatment for all patients with complete spinal cord lesions. Four patients died while an inpatient, with meningitis and cystitis leading to the death of 1 and 3 patients, respectively. Cystitis was treated with intravesicular irrigation; an indwelling catheter was placed by a suprapubic cystostomy in four. Cushing was one of the first to report the use of x-ray in a spine patient, in a case that may have been one factor leading to his interest in the nervous system; Cushing also routinely obtained radiographs in those with spinal trauma. These cases illustrate Cushing's dedication to and rapport with his patients, even in the face of a dismal prognosis.

Keywords

Harvey Cushing; History of neurosurgery; Spinal trauma

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Harvey Cushing was a pioneer of neurosurgery.¹⁻⁸ Although he is best known for his work on brain tumors and intracranial pressure,⁹⁻¹⁵ Cushing also made contributions to cerebrovascular neurosurgery,^{16,17} radiology,¹⁸ anesthesia,¹⁹ and endocrinology.²⁰ Despite the role that Cushing played in the development of the field of neurosurgery, few know that Cushing was also a spine surgeon.²¹⁻²⁴ Cushing's spine cases while he was at Johns Hopkins have never been reported. This is also the first time Cushing's management of patients with spinal trauma has been described.

Although Cushing would eventually focus on cranial operations, while at Johns Hopkins first as a resident (1896-1900) and then as a faculty member (1901-1912), he was interested in the spine. Cushing had high praise for the complexity of patients with spinal cord pathology: "there are no clinical puzzles more interesting to disentangle, none more confusing when left in a snarl, than those connected with the segmental localization of a cord lesion; the determination from disturbances of function of its transverse extent; a decision as to the recoverability of the injured tracts; and a knowledge of just where the intact arches of the spinal vertebra must be entered in order to expose the disease."²⁵

Cushing also made contributions to spine surgery early in his career. Cushing was one of the first to report the use of x-ray in a neurosurgical patient²⁶; the first paper he wrote (although the second to be published) was a case of a patient who presented after a gunshot wound to the cervical spine with deficits in a Brown-Séquard pattern—and Cushing localized the bullet with x-ray.^{27,28}

While at Johns Hopkins, Cushing managed patients with spinal trauma. We report on 12 of his patients who presented between January 1898 and February 1911 who have never been published before and are important in understanding both Cushing's management of spinal trauma and his postoperative treatment of spinal patients. They included blunt and penetrating trauma, complete and incomplete spinal cord injury, and both immediate and delayed presentations. Moreover, these patients came from every sector of society, including a physician's brother who had a football injury and an African American laborer who was accidentally struck in the neck while digging graves; the mechanism of injury varies from a man who was shot during a drunken brawl on Christmas day to a teenager who dived into unexpectedly shallow water.

MATERIALS AND METHODS

The surgical records from 1896 to 1912 at the Chesney Medical Archives of the Johns Hopkins Hospital were reviewed and the files of patients who had Cushing on their operative note were analyzed. Because the original files have been destroyed, all of the records obtained, including the images in this article, were from microfilm copies.

Results and Illustrative Cases

Cushing started his evaluation of his spine patients with a history and physical examination; although the motor system and reflexes were carefully assessed, Cushing's greatest interest was in the sensory examination. Tactile sensation was assessed with cotton, painful perception was determined with a pinprick, heat was produced with hot (in some cases

almost boiling) water, and cold was determined by a camel's hair brush moistened with ether. Pages of his charts are devoted to observations from sensory examination, and findings were often also depicted in drawings. In 2 sketches (Figure 1), we see Cushing's representation of saddle anesthesia, with each line depicting a different dermatomal level. The sensory changes in a patient who presented with a lesion at C7 were drawn on a template of the human body (Figure 2); a different patient's sensory deficits are shaded, with the individual dermatomes labeled (Figure 3).

Cushing was fascinated by the crossing of the sensory fibers for pain and temperature in the spinal cord. The patient in case 2 had a unilateral lesion, with right leg paralysis and loss of pain and temperature sensation in his left leg; Cushing sketched the patient's lesion as he envisioned it within a histological section of the cord (Figure 4). While the fact that pain and temperature sensations follow a different anatomic course from tactile sensation is accepted today, at that time, it was highly debated.^{29,30} Cushing is also well-known for his postoperative sketches,^{31,32} and he drew his intraoperative exposure for 2 patients (Figure 1 and Figure 5); he also sketched kyphotic deformity in 2 other patients with compression fractures (Figure 2 and Figure 4).

We report on the 12 patients with spinal trauma that Cushing treated while at Johns Hopkins whose records are available at the Chesney Medical Archives (Table 1, Table 2, and Table 3). The following illustrative cases further highlight Cushing's management of complete and incomplete spinal cord lesions, penetrating and blunt trauma, and immediate and delayed presentations:

Case 5: Penetrating Trauma Causing Incomplete Spinal Cord Injury, With Delayed Presentation—Presentation and Examination. A 48-year-old man presented to the Johns Hopkins Hospital on August 16, 1905, having been referred to Cushing by his physician in Virginia. One month earlier, the patient had been shot through his mouth during an attempted murder, but he had no immediate symptoms. A few days later, the patient noticed a “crick in his neck”; his pain increased substantially, such that it prevented him from working as a tobacconist. His physical examination was quite unremarkable, except that “the most characteristic features were the attitude of his head, which was held in a position similar to that of cases of a high cervical caries [tuberculosis].” X-ray, although inconclusive, was concerning for a lesion of the third cervical body, which Cushing interpreted as possible osteomyelitis. Six days later, the patient worsened substantially:

On the morning of Aug. 22 I came to the Hospital and hearing a message at the front requesting that the patient be sent to the X-ray room, I hurried to the ward for the purpose of speaking with him before he should have left. He was found sitting in the chair on the bridge markedly dyspnoeic [sic], quite blue and with an anxious expression. He spoke with some difficulty and said that he had quite suddenly begun to lose the power of moving his lower extremities and the left arm. Hurried preparations were made to take him to the operating room but before arrangements could be made to put him on the table respiration had practically become impossible. Only after some moments of artificial respiration. . . [was] there any return of spontaneous breathing. . .

Operation. Cushing immediately prepared the patient for an emergent exploratory operation for relief of the presumed spinal cord compression.

Without waiting for the usual preparatory shaving and cleansing, an incision was made along the *posterior* border of the sterno-cleido-mastoid muscle. This incision was quickly carried down *posterior* to the large cervical vessels to the transverse processes of the spine. By blunt dissection the esophagus and pharynx were separated from their spinal attachments and the seat of trouble exposed. A large slough of mucus membrane and underlying soft parts were lifted out of the wound and with a curette the necrosed body of the third cervical and a portion of the two adjoining bodies were removed. The operator did not feel certain that he had penetrated the anterior intraspinal ligament and a direct view of the same was not possible. Inasmuch, however, as the patient's respiration immediately began to improve. . .it was considered best to desist from further exploration. The wound was packed with iodoform gauze down to the diseased vertebral bodies.

Postoperative Course. The patient initially improved substantially. By the end of the day, the "power of movement" had returned to the patient's left arm and leg, and his right leg was also slightly better; his right arm and leg were given electrical stimulation to improve strength. However, several days later, the patient had a rise in temperature and became stuporous. The presence of fluid emanating from the wound that Cushing thought was consistent with cerebrospinal fluid was an ominous sign. Lumbar puncture showed cloudy fluid with an abundance of white blood cells, but no visible bacteria; the patient had intermittent fevers to 105°F. He quickly became "profoundly unconscious," and 15 days after the operation, the patient died.

Autopsy. Cushing attended the patient's autopsy; after removal of the laminae, he found "a small sharp fragment of bone from the remaining portion of the third cervical body that was projecting almost directly into the right side of the cord anteriorly. . .the dense anterior intraspinal ligament was gone entirely and probably had been removed with the fragments of the third cervical body, so that in the depth of the wound made at the operation the dura was exposed." Acute meningitis and cystitis were also noted.

Case 8: Blunt Trauma Causing Complete Spinal Cord Injury, With Delayed Presentation—Presentation and Examination. On September 16, 1908, a 24-year-old man from Clinton, North Carolina, accompanied by his brother, who was a physician, presented with lower extremity paralysis. Four days earlier, the patient had sustained a cervical hyperflexion injury during a football game, developing immediate bilateral lower extremity paralysis. On examination, the patient also had no voluntary movement of the intrinsic muscles of his hands; anesthesia was noted below the second rib, as well as in his arms involving "little more than the ulnar field." Deep reflexes were not obtained in the ankle or knee bilaterally; he also had a priapism. X-ray revealed a possible fracture of the vertebral body of C7.

Operation and Hospital Course. Cushing did not do a laminectomy, because the patient had a complete spinal cord lesion. Instead, 2 days after admission, he performed a suprapubic cystostomy for palliative insertion of an indwelling urinary catheter, and placed the patient

in a plaster dressing. The immobilization from the plaster made the patient considerably more comfortable, although he still required some morphine; 10 days after admission, sacral decubitus ulcers were noted. Upon discharge the patient's neurological examination was unchanged.

Follow-Up. Cushing received a letter from the patient's brother reporting the death of the patient 1 month after discharge:

Everything went well with him as could be, until a few days before his death, he developed a lobar pneumonia over the right side. . . .He remained conscious until the last moments and never gave up hope until the day of his death, and for the last few days his suffering were awful. Among his last conscious thought were not to forget to write you again and thank you for what you did for him. . . .Of course, had we known [he had a complete spinal cord injury] at [the University of North Carolina at] Chapel Hill we would have realized that an operation was useless. But I shall always be glad that I carried him to you and. . . .taking him there prolonged his life several days or weeks at least. Again thanking you for your goodness to us. . . .your life long friend.

Case 9: Blunt Trauma Causing Incomplete Spinal Cord Injury, With Immediate Presentation—

History and Presentation. On October 5, 1909, a 34 year-old man was brought to the Johns Hopkins Hospital by ambulance 2.5 hours after an accident while he was driving his wagon. His only initial symptom was severe back pain. By the time he arrived at Johns Hopkins, he was unable to move his right leg and described paresthesias in both of his lower extremities. His motor examination was “markedly impaired”; his sensory examination was notable for loss of pinprick sensation in the left leg. Deep reflexes were present in both his knees and ankles, and possibly exaggerated on the right. Later in the night, the patient began to describe bilateral shooting pains down his calves and into the soles of his feet; he was unable to void and required catheterization.

Operation. The next morning, 15 hours after the patient's accident, Cushing and his resident George Heuer³³ performed a laminectomy and exploratory durotomy:

A median incision from possibly the tenth thoracic to the fourth lumbar spine. Immediately on dividing the aponeurosis, the tissues brought into view were greatly infiltrated with old blood. The [spinous process] was exposed showing laceration of tissue between two [spinous processes] taken to represent T XII and LI: Here the [spinous processes] were separated for about an inch and muscles and ligaments torn and infiltrated with blood. . . .Finally the five [spinous processes] which were thought would need to be removed were brought clearly into view and with slow and careful use of the rongeur forceps were away so as to expose the cord. It was quite apparent that there was a marked downward bowing of the spinal dura apparently over the backward dislocations of one or perhaps two of the vertebrae.

It was the operators' impression that this was L1 because of the subsequent opening of the dura and the cord as exposure was in the situation of the lumbar enlargement

and almost at its lower end. The dura as stated, was opened and beyond a slight degree of congestion there was no evidence of more than a physiological block of the cord without damage, although the organ was not palpated to any great extent to determine this. Dura was resutured and wound closed in layers as usual.

Cushing also made sketches after the operation, showing the scheme of the fracture-dislocation and the intraoperative exposure (Figure 1).

Postoperative Course. The patient had a remarkable improvement. By postoperative day 1, his paresthesias had subsided and he was able to void spontaneously; by postoperative day 3, he was able to move both legs and was able to distinguish a pinprick in the left leg except for the outer side of the leg and foot. Several days later, his radiculopathy also ceased. He was discharged after 27 days with his sole neurological deficit being decreased sensation on the outer half of his left foot.

DISCUSSION

The best treatment of spinal trauma—including when to perform an operation—was the subject of contentious debate at the turn of the last century. Some argued that all cases of spinal trauma should have an immediate operation, citing cases where a physician initially thought that the patient had a complete spinal cord lesion, but the patient made significant improvement after a decompressive laminectomy.³⁴⁻³⁶ Others, including Theodore Kocher in Switzerland, found little benefit to surgery in patients who had a complete spinal cord lesion,^{37,38} indicated by Bastian's principle of loss of reflexes, voluntary motion, and sensation below the lesion.³⁹⁻⁴¹

Cushing's views on the best treatment of spinal trauma evolved while he was at Johns Hopkins. In 1905, Cushing advocated operating immediately on patients who presented with a complete spinal cord lesion, writing that “only in the long-standing cases, therefore, which present [with] undoubted evidence of transverse destruction. . . is an operation to be considered utterly futile.”²⁵ However, by 1910 he came to believe that all complete spinal cord lesions should be treated nonoperatively: “[total transections], if it can be recognized without qualification, should not be meddled with, as the condition is hopeless beyond with repair with or without surgical intervention. [Partial transections] may and should be operated upon as soon as the diagnosis is made. . . to free it from pressure and relieve it from the effects of a progressive edema.”⁴²

A little known fact was that some physicians in America and England in the late nineteenth century treated patients differently based on their mechanism of injury. Coal mining and the railway were critical to the industrial revolution, which in turn increased the frequency of occupational trauma. Some argued that patients with a late presentation of deficits after this type of trauma—especially railroad accidents—including patients with radiculopathy, spasticity, and even paraplegia, were either intentionally faking their symptoms in order to sue newly developed corporations, or had unintentionally produced them from their posttraumatic “hysteria.” Even in the 1890s, people with occupational trauma were categorized by some physicians with different patients who presented with what would be referred to today as posttraumatic stress disorder, and diagnosed with “the railway spine.”

Such patients were not offered operations.⁴³⁻⁴⁹ Clearly, given that 5 of Cushing's 12 cases reported here were in miners or railroad workers, he did not believe such social theories, which had strong racial and socioeconomic overtones.

Cushing operated on all of his patients who presented with incomplete spinal cord injuries. His greatest success was the 1 patient in this series who presented acutely with an incomplete spinal cord lesion: the patient in case 9 presented with substantial motor and sensory deficits, but Cushing performed a laminectomy and exploratory durotomy approximately 15 hours after the accident, and the patient was discharged less than a month later with minimal neurological dysfunction.

Of the 12 cases presented here, 5 were patients with complete spinal cord injuries, and he performed spinal operations on 3. In case 1, Cushing likely removed the bullet because he thought it was responsible for the patient's septicemia; in case 4, the patient presented immediately with intact reflexes, and at this point Cushing still thought immediate presentations of complete spinal cord lesions should undergo a laminectomy; in case 6, the laminectomy was a component of the wound debridement for the wound infection from the patient's index operation, performed by a different surgeon. Nonetheless, the disappointing results in these 3 cases likely influenced the transition of Cushing's reasoning to view all complete spinal cord lesions as best treated nonoperatively. Moreover, Cushing came to believe that hyporeflexia was not an absolute requirement for a complete lesion: "it is possible that we cannot rely as definitely as Bastian would have had us believe, on the permanent as well as immediate abolition of the deep reflexes in cases of total transaction."⁴²

The postoperative (or nonoperative) management of patients with spinal trauma was complex. To prevent surgical site infections, wounds were covered with silver nitrate or zinc. In case 6, where Cushing suspected a wound infection from a prior laminectomy, the incision was left open to close by secondary intention. At the end of the operation, the wound was packed with iodoform gauze; subsequently, it was dressed with many different solutions, including benzoyl-peroxide suspended in olive oil.

The management of the paralytic bladder was difficult. Incontinence predisposed to decubitus ulcers and wound infections. Urinary retention was relieved by intermittent catheterization, every 12 or 8 hours. However, in the era before antibiotics, even intermittent catheterization often led to urinary tract infections, which were seen in all 12 of Cushing's trauma patients—leading to death in 3. Treatment for cystitis involved Halsted's method of intravesicular irrigation: rinse "the urethra to cleanse it. . . When sphincter gives way and fluid begins to flow into bladder. . . force fluid into bladder until considerable pain is felt by patient, then withdraw nozzle and allow fluid to be voided."⁵⁰ Up to one liter of Thompson's fluid, a combination of Borax and glycerin,⁵¹ or 50% boric acid were used. It is not surprising that Cushing turned to placing indwelling catheters through a suprapubic cystostomy in his patients who had spinal trauma (which is still used by some in patients with spinal cord injuries).^{52,53}

Bowel dysfunction was yet another problem. One patient required an extensive regimen: “castor oil has been necessary at least every other night, in addition to regular [glycerin] enemata [every morning and] several times manual breaking up of impacted fecal material.” Decubitus ulcers of the sacrum or the heels were seen in 6 of the 12 patients. Initially treated with silver or zinc, more extensive cases were cleansed with alcohol, dressed with bismuth or boric, and compressed with pressure bandages. There were also unexpected complications: the patient in case 3 became very agitated, delirious, and had a marked tremor—his delirium tremens subsided upon treatment with daily whiskey!

While much has been written about Harvey Cushing's decision to specialize on surgery of the nervous system,⁵⁴⁻⁵⁸ the role that Cushing's early interest in spine may have played has not been fully recognized. The patient with the gunshot wound to the cervical spine that Cushing described in the first paper he wrote presented less than 2 months after he had started his residency in 1896. Some have argued that this spine patient was critical to the development of his interest in neurological disease.⁵⁹ In 1923, Cushing gave the presidential address of the American Neurological Association where he described the influences that led him to specialize in neurosurgery. In this paper, Cushing cited this initial case, saying “though at the time I was much more absorbed in Roentgen's recent discovery (x-ray) than in neurology. . .for the next six months with such precision as I could master I plotted out her anesthetic skin fields and followed daily with increasing interest her subsiding paralyzes. The opportunity personally to study for the first time a neurological case. . .made a great impression on me.”⁶⁰ Cushing had much more exposure to spine patients than cranial cases early in his career: between 1901 and 1902 there were no patients admitted to Johns Hopkins with a brain tumor, but there were 14 patients with spinal disease who were managed by Harvey Cushing.⁶¹ Moreover, he included a substantial discussion of spinal disease in his landmark paper entitled “The Special Field of Neurological Surgery,” writing that the resection of a spinal meningioma was the most gratifying procedure in all of surgery and “chief among the findings which make for optimism in neurological surgery.”^{25,42,62}

Cushing's routine usage of x-ray in spine patients was revolutionary. This initial case was among the first to report the use of x-ray in a neurosurgical patient, and he continued to routinely obtain radiographs on his patients with spinal trauma. Cushing recorded x-ray findings, which were often critical to his assessment. In case 5, when the patient rapidly developed paraplegia, it was this x-ray that made Cushing consider osteomyelitis, for which he performed a corpectomy instead of a laminectomy.

Finally, the illustrative cases highlight Cushing's devotion to and rapport with his patients, even in the face of a dismal prognosis. In case 5, Cushing, upon learning that his patient was leaving to obtain an x-ray, went to assess the patient; by being attentive to his patients he was the first to learn that the patient had a sudden onset of paraplegia. Before endotracheal intubation was used, a compression of the spinal cord at C3 would have inevitably led to respiratory paralysis and death. Without wasting a moment, Cushing took the patient to the operating room, and perhaps too anxious to relieve the spinal cord compression, without the preparatory cleansing measures, he began an anterior cervical corpectomy—an operation that there is no evidence in the archives he had ever performed before. Case 8 provides a moving testimony to the admiration Cushing's patients had for him. Although the young

man must have been sorely disappointed when he arrived from North Carolina to learn that he was not an operative candidate (as he had a complete spinal cord lesion), Cushing still had a powerful impact on him. In fact, the patient's brother later wrote to Cushing in a letter signed "your life long friend," that as the patient lay on his death bed, suffering from a severe pneumonia, "one of his last conscious thoughts" was to have the family write to Cushing and thank him. As Edward Laws has said, the basis of tradition in neurosurgery is doing well what has been done before.⁶³ All neurosurgeons can strive for the level of dedication to and rapport with patients that Cushing had with these spinal trauma patients.

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FIGURE 1.

Case 9: A 34-year-old man presented 2.5 hours after an accident with difficulty moving his right leg, paresthesias in his lower extremities, and severe back pain. Although there is no note of “saddle” or perineal anesthesia, Cushing made drawings of this presentation from the dorsal lithotomy (A) and lateral (B) views. Twelve hours after presentation, Cushing performed a laminectomy and exploratory durotomy. He has depicted the fracture-dislocation (C), specifically noting the “area of fracture-disloc”; he has also sketched the exposure (D), labeling the “area of fracture anterior” between T12 and L1, and “posterior curve” of the spinal cord. The patient was discharged with no residual motor symptoms

FIGURE 2.

Case 3: A 38-year-old African American man presented after having been accidentally struck in the neck while digging graves. The patient's sensory examination was drawn on a template of the human body. The shaded areas in (A) and (C) demarcate areas of intact sensation; the line in (B) shows the line above which sensation was intact, and below which sensation was lost, consistent with a lesion at C7.

FIGURE 3.

Case 10: A 25-year-old miner who had been crushed by falling coal 1 year earlier presented with difficult walking and bowel and bladder dysfunction. Examination was remarkable for bilateral paralysis of dorsiflexion and numbness involving the L5 and sacral dermatomes. Cushing often depicted where the deficits of his spinal patients on an embryonic model (A). Not only are the areas of sensory impairment shaded for this patient (B), but the individual dermatomes are also labeled. Intraoperatively there was “considerable displacement, [with] the first lumbar being dorsally much more prominent than the other vertebrae,” and he sketched the kyphotic deformity (C) *in his operative note*.

FIGURE 4.

Case 2: A 38-year-old man presented 2 months after a coal mine injury with deficits in a Brown-Séquard pattern, including right leg weakness and loss of sensation of pain and temperature on the left leg. Cushing has drawn the spinal cord as he envisioned the lesion in a histological section, depicting the crossing of pain and temperature fibers upon entering the spinal cord (A). On the right side, he has written “sensory OK, Motor (pyramidal) paralysis”; on the left side, he has written “Motor (pyramidal) OK, sensory pain (thermic) paralysis.” Cushing performed a laminectomy and exploratory durotomy and he sketched a diagram of the patient's compression fracture from a sagittal view (B).

FIGURE 5.

Case 3: A 32-year-old miner presented to the Johns Hopkins Hospital 8 days after having been crushed by coal with bilateral lower extremity paralysis and paresthesias. Three days later, Cushing performed a laminectomy that revealed a fracture-dislocation with anterior subluxation. He sketched his depiction of the injury from a sagittal view (A) and drew the intraoperative view after the 3-level laminectomy (B).

TABLE 1

Cushing's Trauma Patients at the Johns Hopkins Hospital, 1898-1905^a

	Case			
	1	2	3	4
Age and sex	38 M	38 M	32 M	38 M
Hometown	Baltimore, MD	Reefton, WV	Clarksburg, WV	Baltimore, MD
Occupation	Unknown	Railroader, coal mines	Coal miner	Gravedigger
Mechanism of injury	Gunshot wound to back, quarrel December 25, 1897 in a bar	Struck by freight cars, dragged 60 feet	Struck on the back by falling coal	Grave digging, accidentally struck in the neck
Time before admission	3 weeks	2 months	8 days	Same day
Admission date	01/12/1898	01/10/1900	12/05/1902	09/09/1905
Presenting symptoms	Paraplegia, no sensation below mid-back	Bowel and bladder incont., R leg paralysis	Back pain, parasthesias, B LE paralysis	B LE paralysis & sensory loss in hands & legs
Physical examination	Paralysis of LEs, T5 sensory level, hyporeflexia	Brown-Sequard pattern: R leg paralysis, L sensory deficit	B LE paralysis, B LE hyporeflexia	B paralysis of elbow extension, wrist & hand m.
Time between admission and OR; type of operation	7 weeks later, 6 level laminectomy, bullet removal, ex. durotomy	5 weeks after admission, laminectomy and ex. durotomy	3 days later, laminectomy & suprapubic cystostomy	1 day later, C4-C7 laminectomy & suprapubic cystostomy
Intraoperative notes	Cord normal, significant bleeding	Compression of L1	Anterior dislocation causing cord compression	Unusual mobility of vertebrae, no fx made out
Complete or incomplete SCI; diagnosis	Complete, transverse lesion of T5	Incomplete, compression fracture of L1	Incomplete, fx-dislocation of T12/L1	Complete, fx-dislocation at C5/C6
Hospital course	Recurrent UTIs & fever	Sacral decubitus ulcers	Delirium tremens treated with whisky	Respiratory difficulty & fever (105.7° F)
Outcome	Died POD 1, likely from UTI	"Little improvement" no follow-up	Neurological = "practically unchanged"	Died POD 1
Autopsy findings	Laceration of cord, acute cystitis	N/A	N/A	Fx of C5/C6, compression of cord, cystitis

^aOR, operating room; SCI, spinal cord injury; M, male; LE, lower extremity; ex., exploratory; UTI, urinary tract infection; POD, postoperative day; incont., incontinence; R, right; L, left; N/A, not applicable; B, bilateral; fx, fracture; m., muscles.

TABLE 2

Cushing's Trauma Patients at the Johns Hopkins Hospital, 1905-1908^a

	Case			
	5	6	7	8
Age and sex	48 M	21 M	47 M	24 M
Hometown	Virginia	Boomer, WV	Stanleton, VA	Clinton, NC
Occupation	Tobacconist	Coal miner	Railroader	Student
Mechanism of injury	Attempted murder, gunshot wound	Mining, caught between rail car & roof of tunnel	Working on a telegraph pole, fell 20 feet	Hyperflexion football injury
Time before admission	1 month	2 months	2 weeks	4 days
Admission date	09/16/1905	11/09/1907	07/09/1908	09/16/1908
Presenting symptoms	Neck pain and immobility	LE paralysis, laminectomy by outside physician, wound infection	B LE paralysis, bowel and bladder incontinence	No motion or sensation in body & legs
Physical examination	Neck rigidity, similar to cases of cervical tuberculosis	Flaccid lower extremities, bladder distension	LE paralysis, sensation absent below mid-abdomen	Paralysis of intrinsic hand m. and B LE, C8 sensory deficit
Time between admission and OR; type of operation	6 days later, emergent C3 corpectomy, partial C2/C4 corpectomy	1 week later, suprapubic cystostomy, debridement of laminae	N/A	2 days later, suprapubic cystostomy
Intraoperative notes	Necrotic vertebral body of C3	No complications or findings	N/A	N/A
Complete or incomplete SCI; diagnosis	Incomplete, fracture of C3 with cord injury	Complete, thoracolumbar fx	Complete, fx-dislocation of T9/T10	Complete, x-ray = Fx of C7
Hospital course	Fever, CSF leak, LP = numerous WBC	UTI/pyelo, sacral decubitus ulcer	Chills, distended abdomen, min UOP	T = 104°F, intermittent priapism
Outcome	Died, likely due to meningitis	Resolution of UTI, no motor improvement	Died, likely urinary tract infection, acute pyelo	Died at home of pneumonia 1 month later
Autopsy findings	Portion of C3 projecting anteriorly into cord, meningitis	N/A	Fx-dislocation at T9 w/section of cord, acute pyelo + peritonitis	N/A

^aOR, operating room; SCI, spinal cord injury; M, male; CSF, cerebrospinal fluid; LP, lumbar puncture; WBC, white blood cells; LE, lower extremity; fx, fracture; UTI, urinary tract infection; pyelo, pyelonephritis; N/A, not applicable; B, bilateral; UOP, urine output; m., muscles; T, temperature.

TABLE 3

Cushing's Trauma Patients at the Johns Hopkins Hospital, 1909-1911^a

	Case			
	9	10	11	12
Age and sex	34 M	25 M	19 M	22 M
Hometown	Baltimore, MD	Tunnelton, WV	Knoxville, TN	Salem, WV
Occupation	Driver	Coal miner	Clerk	Farmer
Mechanism of injury	Accident while driving a wagon	Crushed by falling coal	Dived into a lake, water was 3 feet deep, hit neck on rock	Roof collapsed, timber struck pt on head
Time before admission	2 hours 30 minutes	1 Year	18 Months	2 Months
Admission date	10/05/1909	12/28/1909	01/13/1910	02/05/1911
Presenting symptoms	Paralysis of R leg, B LE paresthesias	Ambulates with crutches, urinary & fecal incontinence	Bilateral LE paralysis, bowel and bladder incontinence	B paraplegia, partial loss of sensation below thorax
Physical examination	Some motion of B LE L > R, sensory deficit in L LE	Weakness in dorsiflexion B LE, numbness in LE below L5	B weakness in elbow/wrist ext, partial sensory loss at C7	No hand grip, LE spasticity and hyperreflexia
Time between admission and OR; type of operation	Next day (15 hours after accident), laminectomy from T10-L2, ex. durotomy	11 days later, laminectomy and ex. durotomy	1 week later, ex. laminectomy and durotomy	1 month later, C3-C7 laminectomy and ex. durotomy
Intraoperative notes	Separation by an inch of T12 and L1	L1 prominent dorsally	Irregularity in the lamina and the vertebral body of C6	Arachnoid accidentally pricked, CSF leak
Complete or incomplete SCI; diagnosis	Incomplete, fx-dislocation of T12-L1	Incomplete, compression fracture of L1	Incomplete, C6 fx	Incomplete, unclear
Hospital course	Urinary retention requiring cath	Wound dressed with Silver and gauze	Cath no longer necessary after operation	Nothing notable documented
Outcome	Improved: no residual motor symptoms or paresthesias	No change in motor exam but better bowel & bladder control	Improved: less incontinence and no requirement for cath	Partial improvement in sensation in legs
Autopsy findings	N/A	N/A	N/A	N/A

^aOR, operating room; SCI, spinal cord injury; M, male; R, right; B, bilateral; LE, lower extremity; L, left; ex., exploratory; fx, fracture; cath, catheterization; N/A, not applicable; CSF, cerebrospinal fluid.