

# George J. Garceau (1896–1977) and the first introduction of the “filum terminale syndrome”

Erfanul Saker<sup>1</sup>  · Marcus Cox<sup>1</sup> · Marios Loukas<sup>1</sup> · Rod J. Oskouiian<sup>2</sup> · R. Shane Tubbs<sup>1,2</sup>

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## Introduction

The filum terminale syndrome is associated with spinal cord tethering and an abnormally positioned conus medullaris below L2–3 and often results in symptoms of a tethered cord [12]. This syndrome was first noticed and documented in the nineteenth century when the neurological, urological, and orthopedic manifestations associated with spina bifida occulta (SBO) were referred to as occult spinal dysraphism [8]. In 1910, Fuchs [1] speculated that incontinence seen in myelomeningocele patients during spinal flexion was due to increased tension on the distal spinal cord [6]. By 1940, Lichtenstein [7] furthered the concept of cord dysfunction secondary to tethering lesions [6]. However, it was not until 1953 when George J. Garceau (Fig. 1) [3] described the “filum terminale syndrome” (Fig. 2) hypothesizing that tension from an abnormally thickened filum terminale was responsible for spinal cord traction symptoms [6].

Garceau was an orthopedic surgeon whose initial interest began with children and extended eventually to the care of patients of all ages. He was credited with contributing many original, innovative surgical insights and approaches to his field, particularly in such defects and diseases as club foot, congenital dislocation of the hip, Perthes disease, slipped epiphysis of adolescence, scoliosis, paralytic results of

poliomyelitis and cerebral palsy, bone tumors, and degenerative joint disease [13].

## Early life

George Joseph Garceau was born on May 24, 1896, in Centerville, Minnesota, USA. A practicing Roman Catholic, he was the son of Joseph Samuel, a mining engineer and a maker of machinery, and Mary (Pelletier) Garceau [13]. He received his elementary education at



**Fig. 1** Photograph of George Joseph Garceau

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✉ Erfanul Saker  
esaker@sgu.edu

<sup>1</sup> Department of Anatomical Sciences, St. George's University, Grenada, West Indies

<sup>2</sup> Seattle Science Foundation, Seattle, WA, USA

## THE FILUM TERMINALE SYNDROME

(THE CORD-TRACTION SYNDROME)\*

BY GEORGE J. GARCEAU, M.D., INDIANAPOLIS, INDIANA

*From the James Whitcomb Riley Hospital, Indiana University School of Medicine, Indianapolis*

This communication is a report of our observations made during the study and treatment of three patients presenting the symptoms of a progressive spastic paralysis. It concerns especially the pathological changes found when these patients were subjected to exploratory laminectomy. A diligent search of the available literature failed to reveal a similar clinical report, although such may exist.

In 1945 we became interested in the Arnold-Chiari syndrome. This symptom complex, usually associated with deformities of the spine and spinal cord, was first described by Arnold in 1894 and by Chiari in 1895. Many articles have appeared in the neurological literature since the publication of these original papers.

In a recent publication, McKenzie and Dewar concluded that in twenty-one of twenty-four patients operated upon for scoliosis with paraplegia, the cause of the paralysis was a tight dura stretching over the angulated spine. The review of the literature on the subject of paralysis associated with scoliosis supports that opinion. The onset of the paralysis in thirty-three of forty-one cases reported was between the ages of thirteen and nineteen years. Two of our patients were thirteen years old at the onset of paralysis. The third patient was fourteen years old at the onset of the symptoms; however, although he recovered and remained well for four years, the symptoms again recurred at the age of seventeen years.

Ingraham and Lowrey reported that about 25 per cent. of children have defects of the vertebral laminae and that incomplete closure is frequently observed.

Steele reported the Arnold-Chiari malformation to be a frequent factor in cases of hydrocephalus, causing a block of the fourth ventricle and obstruction of the cerebro-spinal-fluid circulation.

Lichtenstein described the distant (remote) neuro-anatomical complications of spina bifida. He reported that the cauda equina may be short, causing retention of the infantile position of the conus medullaris.

Harmeier in 1933 and Tarlov in 1938 described the normal structure of the filum terminale and concluded that it contained all the histological tissues of the spinal cord.

Reimann and Anson and later Anson alone studied an instance of a sacral cord in an anatomical laboratory specimen, the only sacral cord in 129 specimens. The spinal cord terminated at the first and second lumbar vertebral level in 95 per cent. of 129 adult specimens.

Kleinberg recently reported a case of paraplegia occurring in a patient with a congenital scoliosis. He concluded that, if the symptoms do not improve with non-operative treatment, laminectomy supplemented by the necessary additional surgery is indicated.

In the patients who form the basis of this report, progressive spastic palsy developed while they were under observation for other conditions. The first had a congenital scoliosis; the second had recovered from tuberculosis of the spine; the third had been under treatment for an idiopathic scoliosis.

**CASE 1.** In August 1944 a thirteen-year-old white boy was admitted to the Orthopaedic Service for observation and treatment for a rapidly progressing left thoracic kyphoscoliosis, due to extensive congenital malformations of the spine from the second to the seventh thoracic vertebrae (Fig. 1-A). He had

\* Read at the Joint Meeting of the Orthopaedic Associations, London, July 2, 1952.

public schools in White Bear Lake, Minnesota. Garceau attended the University of Minnesota where his undergraduate studies were put on hold by his voluntary enlistment in the Marines. From 1917 to 1919, he served as a sergeant major in the US Marine Corps and with the 2nd Marine Division in World War I [10, 13]. He received military decoration for wounds received during his participation in the Battle of Belleau Wood (June 1–26, 1918) near the Marne River in France. He continued earning merits on his return to the university, receiving scholastic cognizance as well as varsity prominence on the football field, ice-hockey rink, and a boxing champion in the Marine Corps [10, 13]. Following completion of his undergraduate studies and receiving his bachelor of science degree in 1921, Garceau advanced his education by attending medical school at Northwestern University [10]. He was married in Indianapolis on June 2, 1927, to Julia May Davidson and had two daughters: Mary Dolores and Diana Ruth [13].

### Early career

In 1925, Garceau received his doctor of medicine degree following completion of an internship at the Indianapolis Methodist Episcopal Hospital, Indianapolis, Indiana, USA. He completed his residency at St. Francis Hospital, Miami Beach, Florida, USA, in 1926–1927 and at Shriners' Hospital for Crippled Children, Chicago, Illinois, USA, in 1927–1928 [13]. His postgraduate training also included house-officer positions in Boston and a return to Indianapolis [10]. From 1928 to 1933, Garceau was a surgery resident at Indiana University Hospital and was appointed the first chief of orthopedic surgery at the James Whitcomb Riley Hospital for Children [13].

From early on in his career, Garceau began training orthopedic residents and conducted formal classes in anatomy, pathology, and physiology. He developed a residency-rotation/training program that encompassed six hospitals, including Marion County General, Veterans Administration, Methodist Episcopal, and St. Vincent's hospitals in Indianapolis. His purpose was so that residents would have the greatest possible contact with the private sector before they joined the professional ranks [10, 13]. Those fortunate to work with and be mentored by Garceau raved about the invigorating experience to observe his examination, evaluation, and approach to a problem. "As a teacher, his clarity and emphasis on priority and perspective were outstanding. As a surgeon, his insight and approaches were original, innovative, and ingenious, yet he never endangered life or limb. As a clinician-reporter, his absolute integrity can never be forgotten" [10].

### Contributions to medicine and the tight filum terminale syndrome

In 1940, Garceau [2] first described transposition of the tibialis anterior tendon in recurrent congenital clubfoot and published his findings in the *Journal of Bone and Joint Surgery* [2, 5]. Based on these trials, he reported 77 % good and excellent results in forefoot adduction correction, and 93 % in inversion deformity correction [5]. The clinical appearance of feet was classified according to criteria established by Garceau based on observations he made on residual metatarsus adductus, heel varus, and equinus and offers a morphologic way of evaluating clinical results [5]. Since then, the tibialis anterior tendon transfer has been used widely in management of residual clubfoot deformity [5].

In 1953, Garceau observed improvement of progressive spastic paralysis following exploratory laminectomy and resection (performed during 1949–1951) of a thick, tight filum terminale in three patients [3, 9]. Prior to the discoveries made in the filum, these patients were initially being observed for other anomalies including congenital and idiopathic scoliosis, and tuberculosis of the spine [3]. In the patient with congenital scoliosis, it was noted that the conus medullaris retained its fetal position resulting in paralysis during the period of rapid growth. In the patient with idiopathic thoracolumbar scoliosis, the tightness of the filum was identified after observing a one-centimeter separation upon sectioning. The third patient experienced signs and symptoms of paraplegia during the period of rapid growth, which improved following sectioning of the filum terminale. Garceau hypothesized that the tension from a tight filum terminale may cause spinal cord symptomatology such as compression over an angulated spine or cord traction resulting in pulling of the hindbrain into the foramen magnum, i.e., Chiari malformation [3, 6]. He published (Fig. 2) his findings in the *Journal of Bone and Joint Surgery* [3] and acknowledged Dr. Robert F. Heimburger, then Associate Professor of Surgery at Indiana University for his contribution to the study. Based on his findings, Garceau was credited as the first physician to attribute neurological sequelae to a taut filum terminale [9, 11].

Garceau contributed many other papers to the medical literature. Among the other noteworthy were "Transplantation of the Iliacus Muscle for Loss of Hip Abductor Power," "Solitary Unicameral Bone Cyst," "A Preliminary Study of Selective Plantar-muscle Denervation for Pes Cavus," and "Congenital Talipes Equinovarus" [13].

### Accomplishments/legacy

Garceau was honored with many citations for his contributions to medicine, and in 1945, some of the residents under his tutelage organized the Riley Hospital Orthopedic Alumni

Association in his honor. This organization continues to be active today and holds an annual fall lecture series known as the Garceau Lectures [4, 10, 13]. These lectures invite leading orthopedic surgery experts to present and discuss the most recent advances in the field of orthopedic surgery.

In 1948, Garceau was appointed Professor and Chairman of the newly established Department of Orthopedic Surgery at Indiana University School of Medicine. In the same year, he served as President of the Clinical Orthopedic Society. His contributions as a member and as President of the American Board of Orthopedic Surgery in 1957 provided excellence and advances in orthopedic educational standards. In 1960, he was appointed Vice President of the American Academy of Orthopedic Surgeons [10]. Garceau guided the Department of Orthopedic Surgery at Indiana for nearly 20 years until his retirement in 1966. In 1967, he was named Distinguished Professor Emeritus [10].

## Death

Garceau ran a private practice in St. Vincent Indianapolis Hospital, where he was Chief of Orthopedic Services for 25 years, and one-time President of the Staff Society. He continued active teaching of residents and served on the hospital's Research and Development Committee until his death on November 5, 1977 after a prolonged illness [10]. In 1974, the library of St. Vincent's Hospital was dedicated in his name [13]. "The full impact of George Garceau's influence is difficult to assess, but it is deeply appreciated by all who have known him and benefited by his noble example" [10].

## Compliance with ethical standards

**Conflict of interest** The authors have no conflicts of interest.

## References

1. Fuchs A (1910) Ueber Beziehungen der Enuresis nocturna zu Rudimentärformen der Spina bifida occulta (Myelodysplasie). *Wien Med Wochenschr* 80:1569–1573
2. Garceau GJ (1940) Anterior tibial tendon transposition in recurrent congenital club-foot. *J Bone Joint Surg* 22:932–933
3. Garceau GJ (1953) The film terminale syndrome (the cord-traction syndrome). *J Bone Joint Surg* 35:711–716
4. Indiana University (2016) Annual Event. In: Department of Orthopaedic Surgery. Indiana University School of Medicine. <http://orthopaedics.medicine.iu.edu/about-us/events/>
5. Kuo KN, Hennigan SP, Hastings ME (2001) Anterior tibial tendon transfer in residual dynamic clubfoot deformity. *J Pediatr Orthop* 21(1):35–41
6. Lew SM, Kothbauer KF (2007) Tethered cord syndrome: an updated review. *Pediatr Neurosurg* 43(3):236–248
7. Lichtenstein B (1940) Spinal dysraphism: Spina bifida and myelodysplasia. *Arch Neurol Psychiatr* 44:792–809
8. Nazar GB, Casale AJ, Roberts JG, Linden RD (1995) Occult filum terminale syndrome. *Pediatr Neurosurg* 23(5):228–235
9. Oi S, Yamada H, Matsumoto S (1990) Tethered cord syndrome versus low-placed conus medullaris in an over-distended spinal cord following initial repair for myelodysplasia. *Childs Nerv Syst* 6(5):264–269
10. Pickerrel D, Scamman DR (1979) George J. Garceau, M.D. 1896—1977. *J Bone Joint Surg Am* 61(5):793–793
11. Tubbs RS, Oakes WJ, Heimburger RF (2004) The relationship of the spinal cord to scoliosis. *J Neurosurg: Pediatr* 101(2):228–233
12. Unsinn KM, Geley T, Freund MC, et al. (2000) US of the spinal cord in newborns: spectrum of normal findings, variants, congenital anomalies, and acquired diseases. *Radiographics* 20(4):923–938
13. White JT, Derby G (1981) The National Cyclopædia of American Biography 60:160–161