Figure 1: Salvador Gil Vernet in his house in Barcelona (ca. 1965).

Figure 2: Salvador Gil Vernet (right) with his students in a practical class of Anatomy at the old Santa Creu Hospital (1918).

SALVADOR GIL VERNET, A PIONEER IN UROLOGICAL ANATOMY

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Introduction

This chapter intends to present the biography and scientific work of Salvador Gil Vernet (1892-1987). He was an outstanding Spanish anatomist and urologist who made extraordinary discoveries in the field of urological anatomy, in particular with his studies on the topographic anatomy of the male pelvis and perineum and who developed the first urethrocentric model of the prostate's regional or zonal anatomy. (Fig.1)

Biography

Salvador Gil Vernet was born in Vandellós, a small town in the province of Tarragona (Spain) on August 10, 1892. As a teenager he showed great passion for the natural sciences and particularly for botany, which he practiced enthusiastically. He dedicated his summer holidays to collecting and classifying a large number of plants. Salvador's dream at the time was to become a professor at the School of Natural Sciences.

In 1909, at the end of his school years, he moved to Barcelona and entered the School of Medicine at the University of Barcelona, from which he graduated with outstanding grades on June 30, 1915. In 1917 he published a new technique for extradural anesthesia in pelvic surgery.[1] In 1920 he was appointed assistant professor at the anatomy department. (Fig. 2) Also in 1920, he married Mercedes Vila with whom he had two children: Salvador (1921-1964) and José María (b. 1922); both would become urologists.

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1 Gil Vernet, S. *La anestesia extradural. Nueva técnica*. Tipografía S. Vilalta, Barcelona. 1917.

Figure 3: Meeting with foreign urologists in Barcelona. From left to right: unidentified, Prof. Salvador Gil Vernet, Dr. José Maria Gil-Vernet Vila, Prof. Ermanno Mingazzini and unidentifieds (ca. 1955).

The same year, he failed in his first competitive exams to become professor of anatomy. Santiago Ramón y Cajal, president of the board of examiners, did not give his vote to Salvador or anyone else, claiming that, in his own words: "In my opinion, there are no appropriate candidates sitting these exams because some of them are too old to start working as scientific researchers, and the others do not have enough experience, as they are too young".

In 1926 Gil Vernet successfully became a professor of the anatomy department at the University of Salamanca and in 1928 he took over the anatomy department at the University of Barcelona, after the death of Prof. Manuel Serés. He also performed functions as Director of the Professional School of Urology at the Hospital Clínico y Provincial of Barcelona, which was founded that year.

A few weeks after the outbreak of the Spanish Civil War, on August 12, 1936, he was dismissed by the, at the time, left-winged Generalitat (Government of Catalonia) because of his conservative ideas, and along with other professors of the University of Barcelona, was relieved of all responsibilities. Persecuted by communists, he chose to leave Spain.

Years later he would remember those times:

> *When, on the evening of August 14 1936, I thought I was saying, 'Goodbye, forever!' to my country from the French ship Cortes II, I experienced emotions that were new to me. Suddenly, I had lost everything that a man can possibly lose, saved only honour and life, and these had been saved thanks only to the charity of the diplomats of Nicaragua and France.*[2]

He first lived in Toulouse, France and then in Italy, where he took part in the foundation of the Mediterranean Urology Association. He eventually returned to Barcelona in 1939, once again joining the anatomy department of the University.

In his double professional role as anatomist and urologist, Gil Vernet often noted his findings in the dissection room and in the operating theatre were uncorrelated to the descriptions in the classical topographic anatomy treatises published in the mid-nineteenth century. These contradictions prompted him to an exhaustive and careful study of male urogenital anatomy, which extended over more than forty years. During his long scientific career Gil Vernet delved into his studies with great discipline and effort. As he used to say: *"Scientific inspiration does not exist if not accompanied by cerebral sweating"*.[3] His findings were crucial to comprehending the pathological processes of the prostate and to designing less invasive new surgical techniques for perineal radical prostatectomy.

Thanks to his huge, daunting work during the 1950s and 1960s, the Urological Service of Prof. Gil Vernet would become one of the most prestigious urologic institutes in the world, a venue hosting urologists such as Prof. Adolphe Steg (France), Prof. Ian Thompson (USA), Prof. Ermanno Mingazzini (Italy) or Prof. Willy Gregoir (Belgium) among many others. (Fig. 3) As a result of the

2 Autobiography of sorts

3 Commentary in Salvador Gil Vernet's obituary, signed by Prof. D. Truano, published in *La Vanguardia* newspaper, on November 1, 1987.

department's great international projection, Gil Vernet maintained fruitful exchanges with Prof. Charles B. Huggins by means of frequent correspondence (Fig.4) and being invited as Lecturer to the University of Chicago.

Salvador Gil Vernet retired from his professional activity when he was 75 and dedicated his last years to the cultivation of roses and lemon trees in his house in Castelldefels playa. He passed away in Barcelona on October 24th, 1987.

Awards

In 1948 he became a full member of the Royal Academy of Medicine and Surgery of Barcelona. In 1950 he received an honorary degree from the University of Toulouse. He received the Pedro Virgili Surgery Award from the Spanish Royal Academy of Medicine and the Antoine Portal Award from the National Academy of Medicine of France in 1965.

He was elected president of the Société Internationale d'Urologie (SIU) from 1967 to 1973 and Honorary President of the Spanish Association of Urology in 1967. He was elected Honorary Member of the Societies of Urology of France, Italy, Greece, Mexico and Colombia. He was a visiting lecturer at Columbia University, and at the Universities of Chicago, Buenos Aires, Bogota, Toulouse, Tokyo, Amsterdam, Johannesburg, Mexico and Munich. In 1986 he received, alongside his son José María Gil-Vernet Vila, the Narcís Monturiol Prize awarded by the Government of Catalonia.

Scientific work

In the 1920s Gil Vernet's research was centered on the study of the topographic anatomy of the male pelvis and perineum, with a specific focus on the bladder, the neural pelvic plexus and the prostate. Following in the steps of German morphologist Hermann Braus, Salvador Gil Vernet considered that it is not enough to determine the "what" and the "how" of an anatomical structure; an answer is needed to the question "what for". This way he strived to develop a functional urogenital anatomy, which better allowed doctors to understand and explain the physiology of urination, erection and ejaculation. Likewise, Gil Vernet provided new insights into the topographic anatomy of these structures, building bridges with surgery and helping to develop more precise and scientific surgical techniques.

Gil Vernet was an untiring worker in a country, Spain, which after its Civil War was a wasteland for scientific research. Thanks to his effort and perseverance he was able to compensate for the economic hardships of the 1940s and published four books dedicated to the study of urogenital anatomy and pathology as well as over 50 journal publications between 1917 and 1977. Possibly his main work was "Patología Urogenital" (Urogenital Pathology, a three-volume work) focused on the study of the prostate, i.e. embryology, regional anatomy, pathology and surgical techniques. (Fig.5)

Some scholars consider it the most outstanding contribution from Spain to studies in urology. "Morphology and Function of Vesico-Prostato-Urethral Musculature" was another fundamental work dedicated to the study of the topographic and microscopic anatomy of the pelvis and the perineum.

In 1930 he started to apply the histotopographic method, a technique of anatomical study (whole-mount sections) in the uro-anatomy laboratory, (Fig.6) which had been described by the German anatomist Otto Kalischer thirty years earlier.[4] With the help of the giant Sartorius-Werke microtome (Fig.7) he obtained frozen sections of the pelvic visceral block from foetal and adult specimens. About 200 preparations were obtained from each specimen, with a thickness of 20 to 50 microns and measuring 12 to 9 centimetres. (Fig.8) Microscopic observation at a magnification of 10x and 100x allowed microscopic dissection of muscle and nerve elements which would otherwise be invisible in macroscopic dissection.

Prof. Gil Vernet annotated the most interesting details in his field books (Fig. 9), which would later be drawn in pencil and Indian ink by the second year students at a scale of 1:7 to 1:15.

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4 Kalischer, O. *Die Urogenitalmuskulatur des Dammes mit Besonderer Berücksichtigung des Harnblasenverschlusses.* S Karger, Berlin.1900.

THE UNIVERSITY OF CHICAGO
CHICAGO 37 · ILLINOIS

THE BEN MAY LABORATORY FOR CANCER RESEARCH
950 E. 59TH STREET

December 6, 1961

S. E. Professor S. Gil Vernet
Escuela Profesional de Urologia
Facultad de Medicina de Barcelona
Barcelona, Spain

Dear Don Salvador:

Your letter was wonderful! I cherish it. Ultimately it will be translated to my grandchildren.

You are the embodiment of the Catalan genius. You are a second Cajal. One of the greatest honors of my life was to become acquainted with you.

On behalf of the University, I invite you to visit Chicago, either before or after your visit to Puebla. We would like to have you give a lecture to our small group which will be truly appreciated. We would like to have you inspect our work. We implore you to be the guest of the University while you are in Chicago. You will be among friends and admirers from beginning to end.

Yours very respectfully,

Charles Huggins

la

Figure 4a & b: Letters from Prof. Charles B. Huggins (1961 and 1963).

Copy

THE UNIVERSITY OF CHICAGO
CHICAGO 37 - ILLINOIS

THE BEN MAY LABORATORY FOR CANCER RESEARCH
950 East 59th Street

13 - 8 - 63

Querido Maestro:

Your work continues the Glorious Science of Spain. How pleased and proud Ramón y Cajal would be to follow your work from its inception to the present. Did you ever see him ? I have never asked you. I am greatly impressed and stimulated by your devotion to Science and to Urology especially. You are the world's most eminent Urologist with many discoveries to your credit. You have built up our finest Clinic with investigations constantly going on and yet you continue to produce work of finest quality. I am full of jealousy and envy of the Escuela Gil Vernet although I realize these are deadly sins.

The GIL VERNET Phenomenon wherein human prostate is separated into 2 physiologically and oncologically different divisions is of permanent value. It is a wonderful discovery.

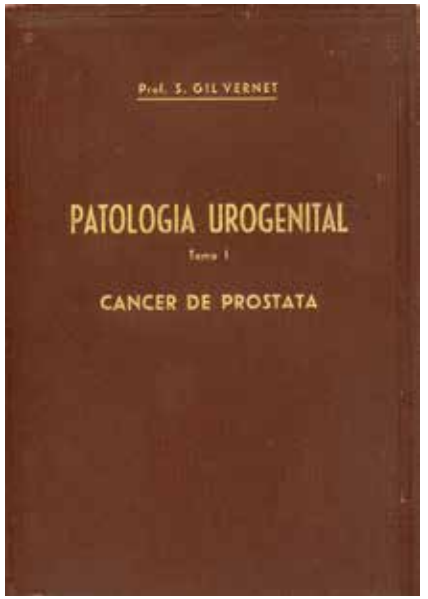
I do not believe that the difference between types of neoplasms in cranial and caudal prostate can be related to different hormonal causes. I prefer to think that there is a different threshold to hormones vis-á-vis cancer in different organs. Both prostates and the seminal vesicle are stimulated to grow by testosterone. We see: Seminal vesicle, no benign tumors, rarely cancer; caudal prostate, always cancer when western man lives to 90 + years, no benign tumors. Cranial prostate: commonest benign, most rare cancer. It is certain that cancer of all sorts is due to a specific change in DNA leading to a defective code. This change for tumors is due to unknown subleties in DNA and occurs much easier in some cells than in other cells.

We feed a female rat 7,12 - Dimethylbenz (a) Anthracene, 20 Mg., a single meal once only. We give her sister, no Hydrocarbon, but a single dose of X-rays, 400 r. Both rats react in the same way, namely tumors are induced. Strangely, tumors occur not anywhere and everywhere but in mammary gland predominantly, often exclusively. Cancer of breast in 25 - 35 days (in other words a few cells of mammary gland are highly susceptible). Now excise the cancers and wait 6 months. The life of rat is preserved. At 6 months benign tumors of the breast appear as a result of Hydrocarbon or X-ray and these modalities are equivalent.

Caudal prostate resembles the most susceptible cells of mammary gland. Cranial prostate resembles the least susceptible mammary cells. It is related to preponderance of smooth muscle cells - fibroblasts in cranial first demonstrated by Don Salvador.

Con mucho amor, respetuosamente, siempre su amigo y admirador.
CHARLES HUGGINS ./.....

Con muchos saludos para Don Salvador, José María y Esposa y Nietos,
Margaret and Charles Huggins



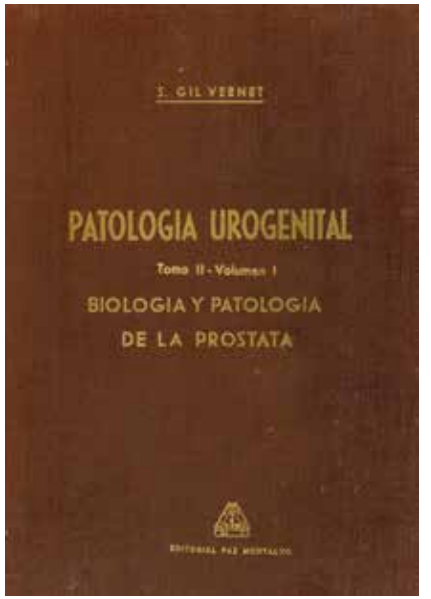


Figure 5a & b: The first two volumes of "Patología Urogenital".

Figure 6: The Uro-Anatomy Laboratory. In the foreground, the tube of the coal stove. To the right in the picture, the giant Sartorius-Werke microtome.

Figure 7: Giant Sartorius Werke microtome (ca.1925) used by Gil Vernet. At present it is in the museum of the Faculty of Biology at the University of Barcelona.

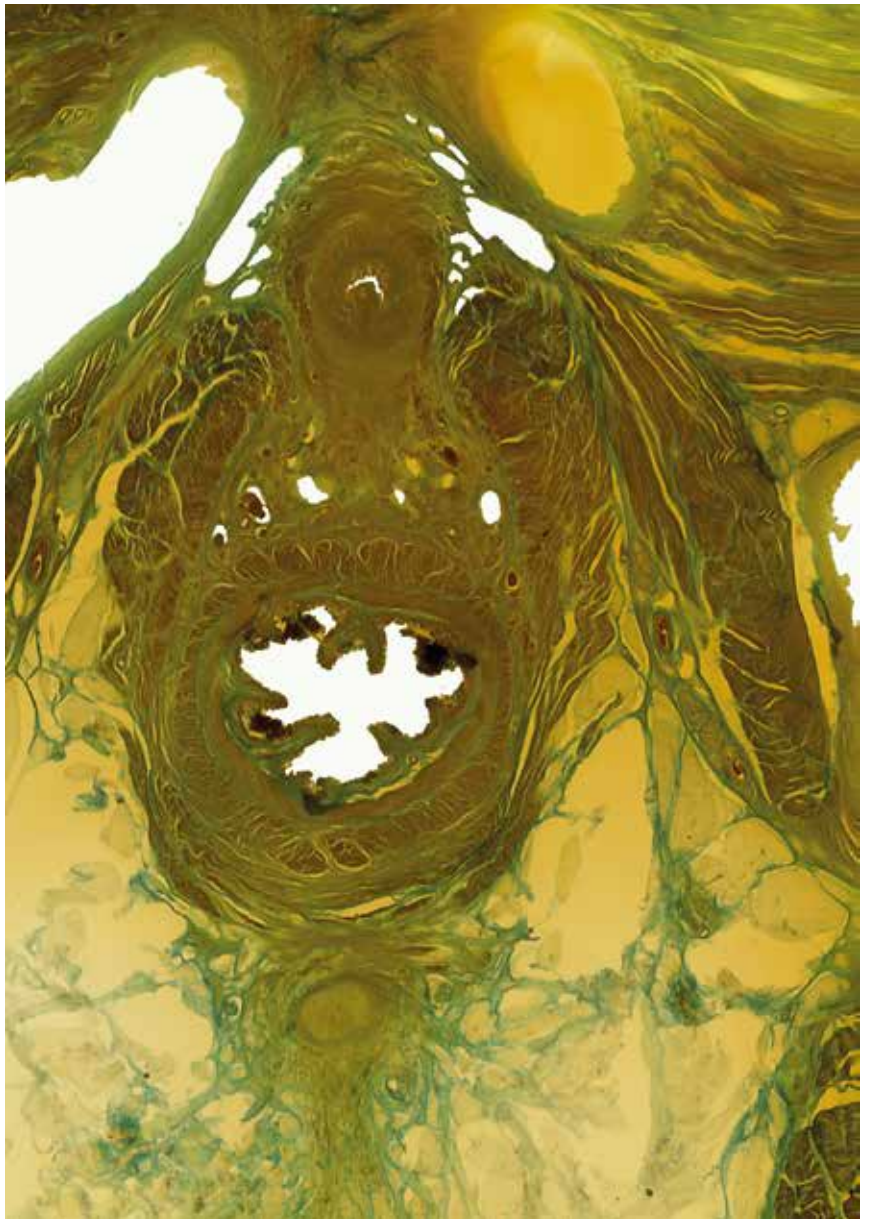


Figure 8: Newborn perineum.Transverse histo-topographic section. Van Gieson trichrome stain.

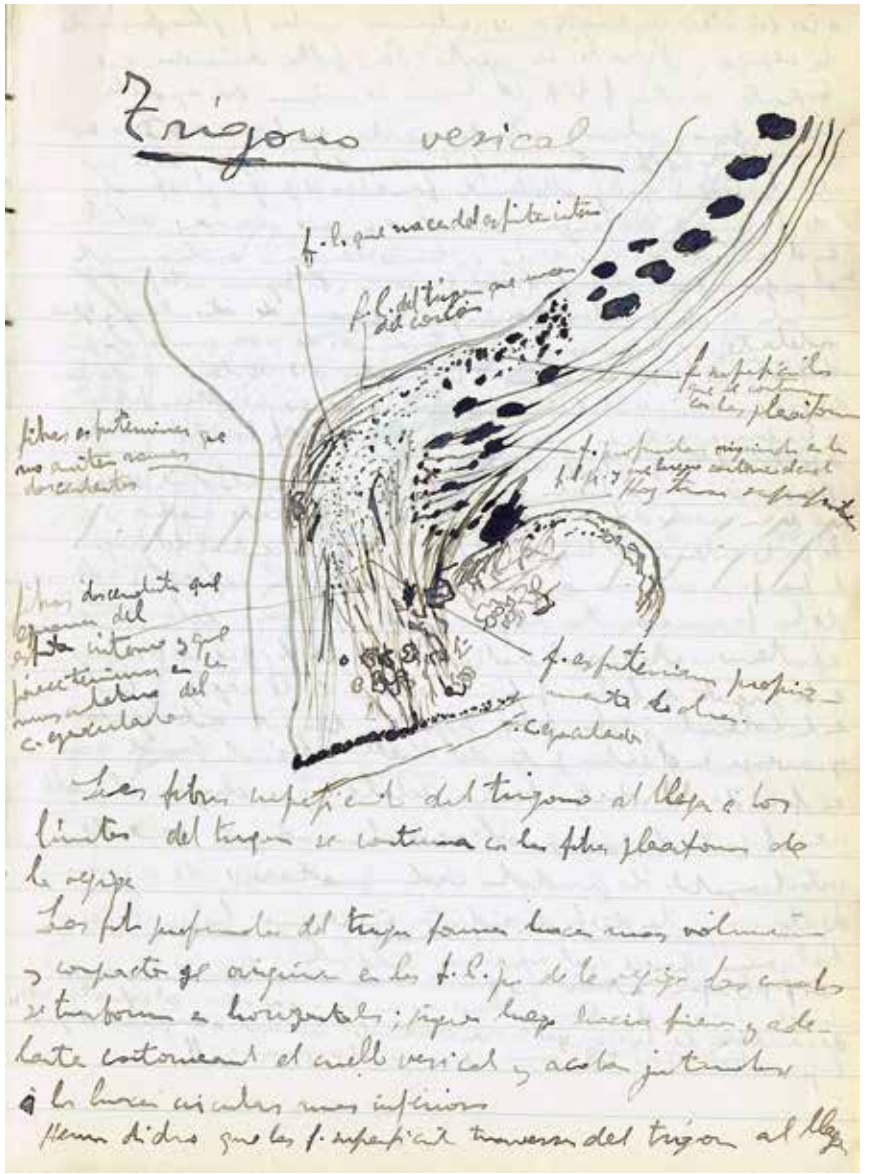


Figure 9: Salvador Gil Vernet's field notebook.

(Fig.10) The sensational richness in the details in the drawings of the histotopographical sections was praised by Charles B. Huggins who wrote: "Let the young surgeon study sagittal sections of the pelvis of the human male, for example the beautiful studies of Gil Vernet".[5] Since 2005, a large number of drawings have been collected and restored, amounting to a total of 604 items, which now comprise the *Salvador Gil Vernet Collection of Urology Drawings*.[6]

The topographic anatomy of the male perineum

His first work, applying the Kalischer's method to the study of the male perineum, was published in 1933.[7] He found that the so-called rectourethral muscle was in fact not a muscle but a complex formed by smooth longitudinal fibres of the external longitudinal layer of the anal canal running to join the fibroconnective tissue of the perineal body and also several dorsocaudal striated fibres of the external urethral sphincter, although these never reached the urethra. (Fig.11)

Gil Vernet considered the term "rectourethralis muscle" a misnomer, and in later studies he coined the term "rectourethralis system".[8] Currently it is known as the "rectourethralis complex".[9] In 1944 he demonstrated that the superficial transverse muscle is made up of fibres that anastomose from the anus's external sphincter with fibres of the bulbospongiosus muscle and never insert into the ischiopubic rami. (Fig. 12) He also studied in great detail the male perineal body and the various muscle and fibroconjunctive elements that make it up.

The external urethral sphincter

In 1836 the German anatomist Johaness Müller[10] described the urethral sphincter as a vertical structure. However, thirty years

5 Huggins, C. *Commentary on the treatment of prostate cancer.* J Urol. 1969, 102 (2):119-120.
6 Gil-Vernet, J.M. *The art of transforming science. Salvador Gil Vernet's modern understanding of urologic anatomy.* Next Door Publishers, Pamplona, 2015.
7 Gil Vernet, S. *Contribució a l'estudi anatómic del periné de l'home pel métode dels talls histo-topogràfics. Treballs de la Societat de Biología.* Barcelona, 1933.
8 Gil Vernet, S. *Patología Urogenital: Cáncer de Próstata.* Book 1. Miguel Servet, Barcelona,1944.
9 Myers, RP. *Practical surgical anatomy for radical prostatectomy.* Urol Clin North Am. 2001, 28: 473-490.
10 Müller, J. *Über die organischen Nerven der erectilen männlichen Geschlectsorgane des Menschen und der Säugethiere.* F Dümmler, Berlin, 1836.

Figure 10: Drawing corresponding to the section in Figure 8. Indian ink on paper, 45 x 28 cm. Artist: L. Roca, 1943.

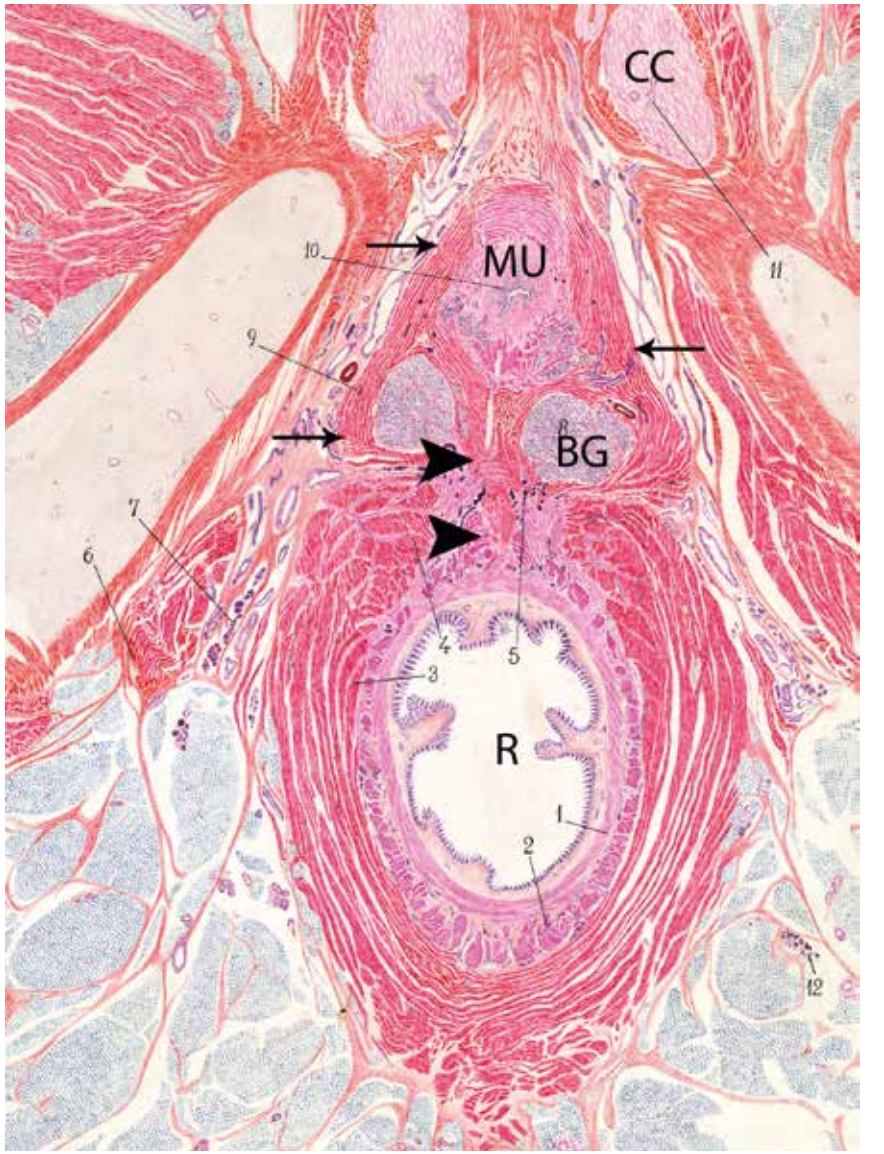


Figure 11: Rectourethralis system (arrowheads). Membranous urethra (MU), external urethral sphincter (arrows), bulbourethral glands (BG), corpus cavernosum (CC) and rectum (R). Male newborn Transverse section. Haematoxilyn-eosin stain. Indian ink on paper, 83 x 49 cm. Artist: L. Sala, ca.1945.

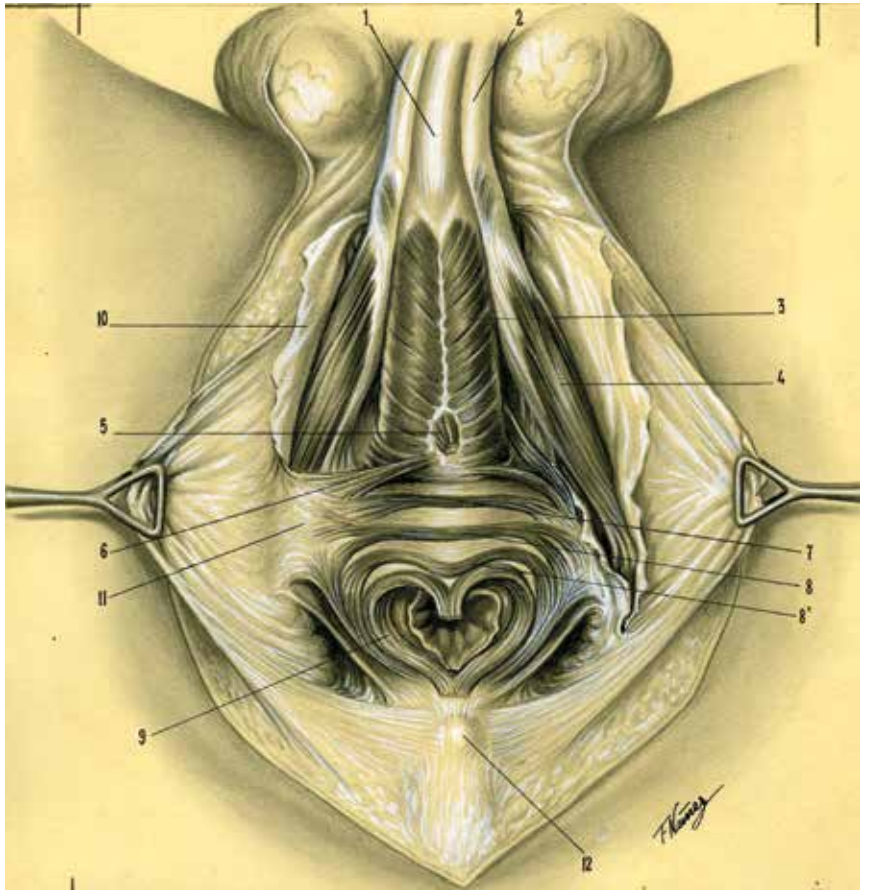


Figure 12: Male superficial perineal muscles. Adult. Mixed media on paper, 25 x 22 cm. Artist: F. Nuñez, ca.1943.

later, his disciple Friedrich Henle[11] considered that the sphincter was actually divided into a proximal portion called *"sphincter vesicae externus"* and a distal portion that was called deep transverse perinei muscle; an error that was included in texts of atlases and anatomy books until the end of the twentieth century.

Gil Vernet was concerned with improving urinary incontinence after radical surgery of the prostate so he set to study the urethral sphincter extensively. What he observed in his dissections and perineal radical prostatectomy did not match the descriptions offered in textbooks. In the 1940s - for the first time in the twentieth century - Gil Vernet described the sphincter as a tubular structure, vertically arranged and consisting of two layers, i.e. an internal layer formed of circularly - and longitudinally - arranged smooth muscle and an external layer of circular striated fibres which were divided into three areas: cranial, medial and caudal. (Fig.13)

He also demonstrated that the deep transverse muscle of the perineum was a non-entity and that the structure surrounding the bulbourethral glands consists of the dorsocaudal fibres of the urethral sphincter that do not insert into the ischiopubic branches.[8,12]

The urethral crest and the posterior prostato-urethral muscular bundle

In 1953 Gil Vernet described a group of dorsal and longitudinal smooth urethral musculature which he referred to as the posterior prostato-urethral muscular bundle, (Fig.14) and which forms the relief of the mucosal fold.[12] This muscular bundle originates below the ejaculatory ducts at the lower pole of the colliculus seminalis, and runs dorsally and downwards ending into the penile bulb. The function of this muscle is to shorten and dilate the infracollicular urethra during ejaculation.

Topographic anatomy of the bladder

Always guided by a clear functional purpose, Gil Vernet

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11 Henle, F. *Handbuch der systematischen Anatomie des Menschen.* Vol. 2. F. Vieweg & Sons, Braunschweig, 1866.
12 Gil Vernet, S. *Patología Urogenital: Biología y Patología de la Próstata.* Book 2. Vol.1. Paz Montalvo, Madrid. 1953.

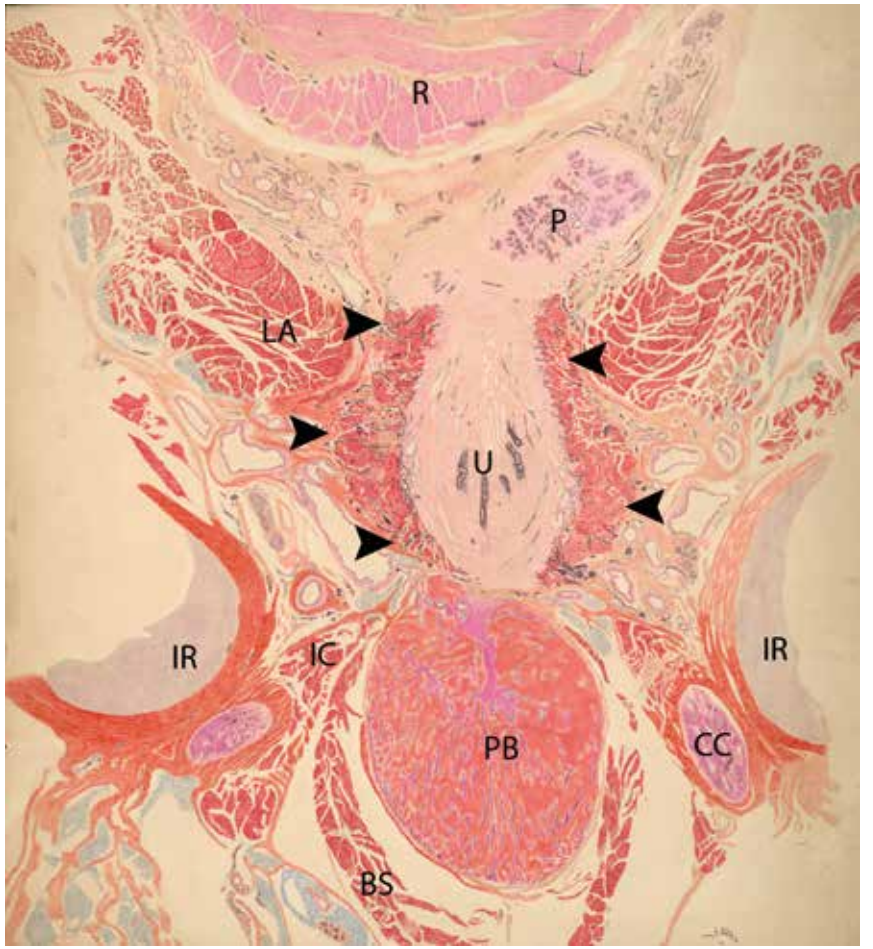

Figure 13: External urethral sphincter (arrowheads). Prostate (P), rectum (R), levator ani muscle, membranous urethra (U), ischiopubic rami (IR), ischiocavernosus muscle (IC), penile bulb (PB), and bulbospongiosus muscle (BS). 6-month male foetus. Coronal section. Haematoxilyn-eosin stain. Indian ink on paper. 71 x 65 cm. Artist: J. Costa, 1944.

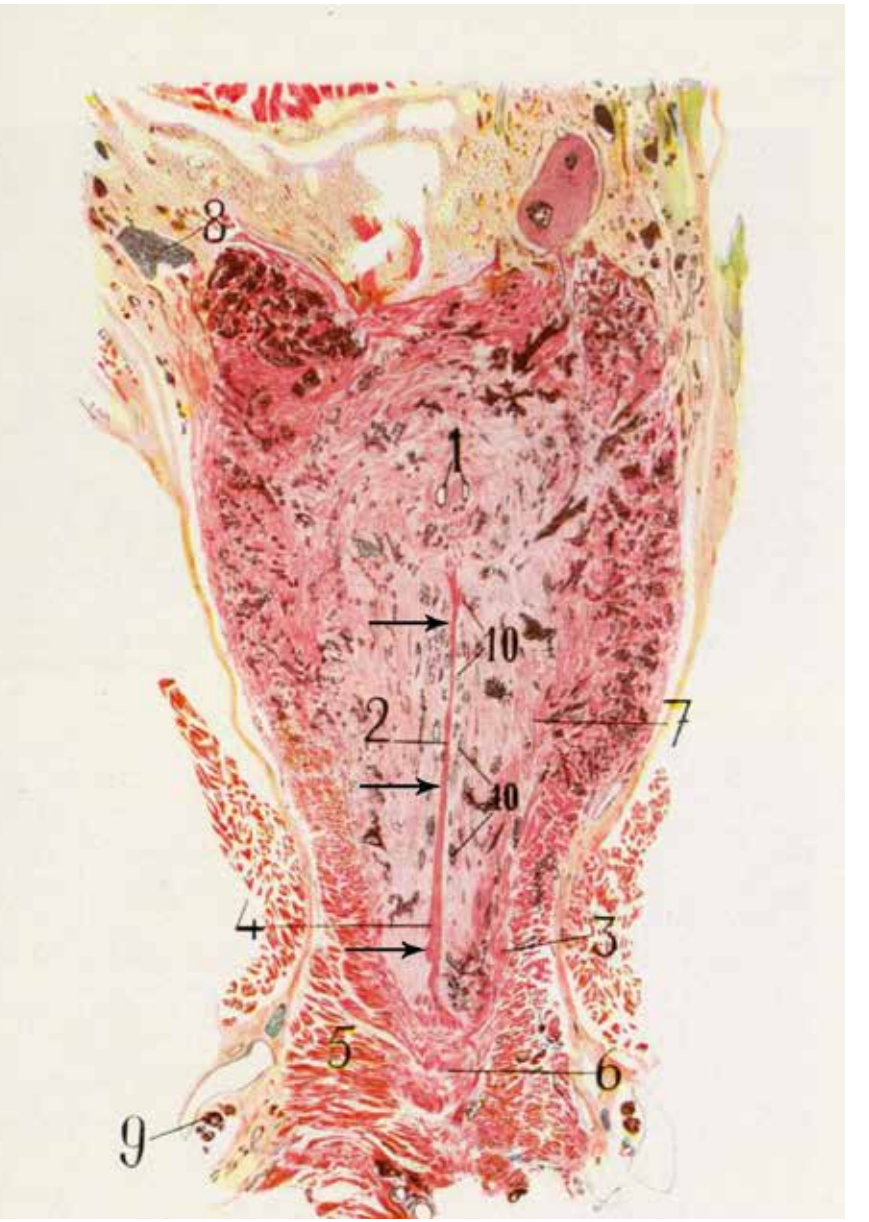

Figure 14: Posterior prostato-urethral muscular bundle (arrows). Coronal section. Haematoxilyn-eosin stain. Indian ink on paper. Unknown artist, ca. 1953.

approached the study of the vesical musculature with the aim to determine the role of the different bundles of the detrusor and their relationship with the bladder neck and the prostate in urination and urinary continence.[12,13] He observed that the pubovesical or puboprostatic ligaments are not really ligaments but fibres of the anterior longitudinal muscle layer of the detrusor covered by the endopelvic fascia, which run downwards and frontwards, running over the prostate and inserting into the pubis.

Gil Vernet was the first to describe the "transverse precervical arc", a triangular structure formed by the intersection of the outer, anterior and posterior longitudinal fibres of the detrusor in the caudal part of the bladder's anterior surface. (Fig.15) The central part of this muscular triangle is mainly occupied by fibres with a vertical direction that come from the anterior wall of the detrusor. This muscular complex was called the "vesico-urethral retrosymphysial system."[12]

In 1953 Gil Vernet described the posterior longitudinal fascia of the detrusor or the detrusor's posterior longitudinal bundle, which descends uninterruptedly from the urachus, running caudally between the ureters and covering the trigone and the dorsal wall of the internal vesical sphincter. Several medial bundles penetrate deep into the prostate, tapering, to end near the opening of the ejaculatory ducts at the colliculus seminalis. (Fig.16) This bundle was described by Eduard Uhlenhuth in the same year, although this author does not describe its caudal extension, which crosses the prostate.[14]

Pelvic plexus neuroanatomy

Since his youth Salvador Gil Vernet took a great interest in the abdominopelvic vegetative nervous system. Thus in 1918, he was the first to describe the inferior mesenteric ganglion in men.[15] In 1926 he published "El Sistema nervioso órgano-vegetativo. Contribución a su estudio anatómico y embriológico",[16] where he

13 Gil Vernet, S. *Morphology and Function of Vesico-Prostato-Urethral Musculature.* Canova, Treviso. 1968.
14 Uhlenhuth, E. *Problems in the Anatomy of the Pelvis: An Atlas.* Lippincott, Philadelphia, 1953.
15 Gallart F, Gil Vernet, S. *El Simpàtic Abdomino-pelvià en el fetus humà. Treballs de la Societat de Biología. Publicacions de l'Institut de Ciències.* Barcelona, 1918.
16 Gil Vernet, S. *El Sistema nervioso órgano-vegetativo. Contribución a su estudio anatómico y embriológico.* Imprenta Badía, Barcelona, 1926.

tried to unravel how anastomoses are formed between the various ganglionic areas during embryonic development. Faced with the enormous complexity of this endeavour, he sought advice from Santiago Ramón y Cajal, whom he had met in 1920 as chairman of the Opposition Committee for the chair of Anatomy. From then on, the men maintained correspondence. (Fig.17)

From 1940 he began to study embryology and neuroanatomy of the pelvic plexus and, specifically, the innervation of the bladder, seminal vesicles, prostate and external urethral sphincter.[8,17] He showed that the vertical extension of the pelvic plexus follows the posterolateral border of the prostate, forming the neurovascular bundles. In the descending part, nerve branches split off that penetrate the prostate gland, membranous urethra and external urethral sphincter, with the terminal branches forming the nerves of the corpus spongiosum and the cavernous nerves. (Fig.18)

He also described a ventral prolongation of the pelvic plexus that forms what he called the anterolateral and anteromedial neurovascular pedicles, which run downwards, giving off branches to the membranous urethra. He wrote:

> *"At every one of the four corners of the rectangle that makes up the prostatic cell, a neurovascular bundle is observed, and those are the bundles which carry the vessels and nerves intended for innervation and irrigation of the prostate, membranous urethra and the cavernous nerves, enabling erection."*[8]

This description of the prostate neurovascular bundles was corroborated by the superb work of Patrick Walsh, which served as the anatomical basis for the development of nerve sparing radical prostatectomy.[18,19] The arrangement of the membranous urethra

17 Gil Vernet, S. *Innervation somatique et végétative des organes génito-urinaries.* Acta Urol Belg. 1964, 32: 265-293.
18 Walsh, P.C. Donker PJ. *Impotence following radical prostatectomy: insight into etiology and prevention.* J Urol. 1982, 128: 492-497.
19 Walsh, P.C. *The Discovery of the cavernous nerves and development of nerve sparing radical retropubic prostatectomy.* J Urol. 2007, 177: 632-1635.

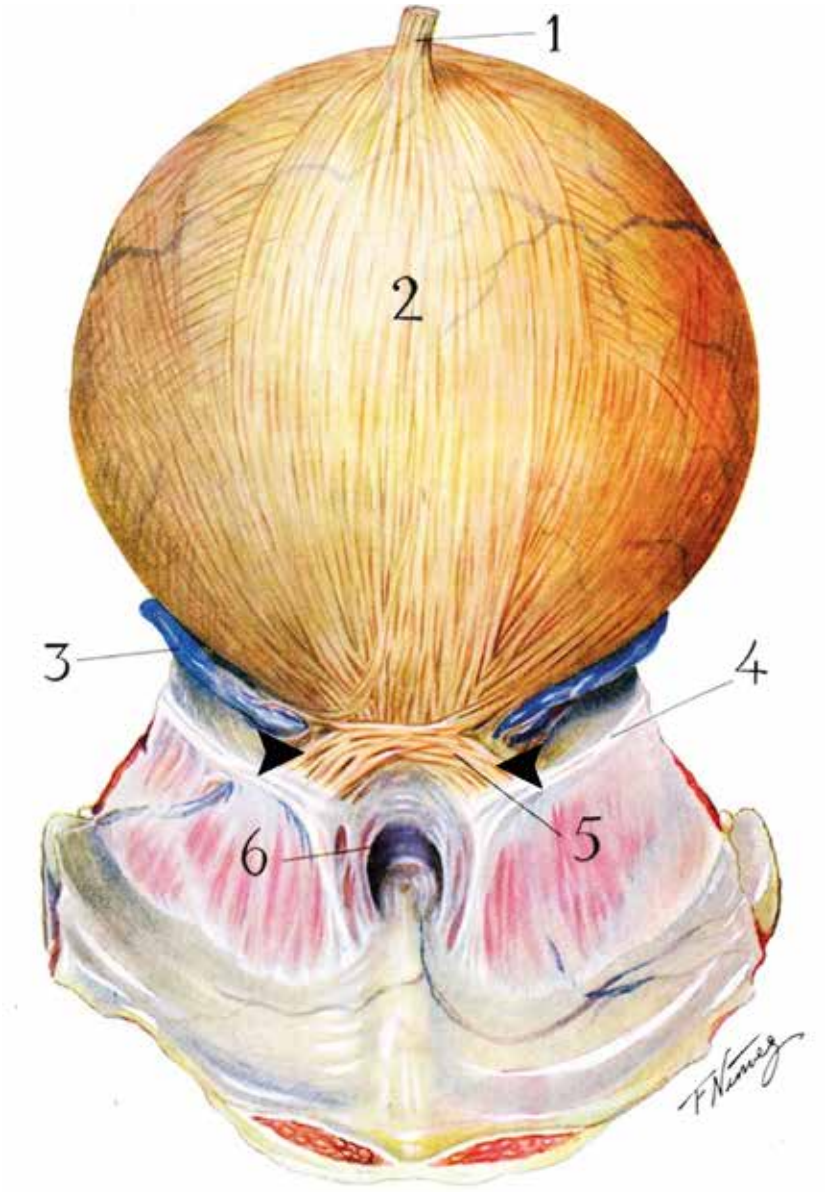

Figure 15: Anterior face of the bladder and space of Retzius. Adult male. Transverse precervial arc (arrowheads). Mixed media on paper. Artist: F. Nuñez ca. 1951.

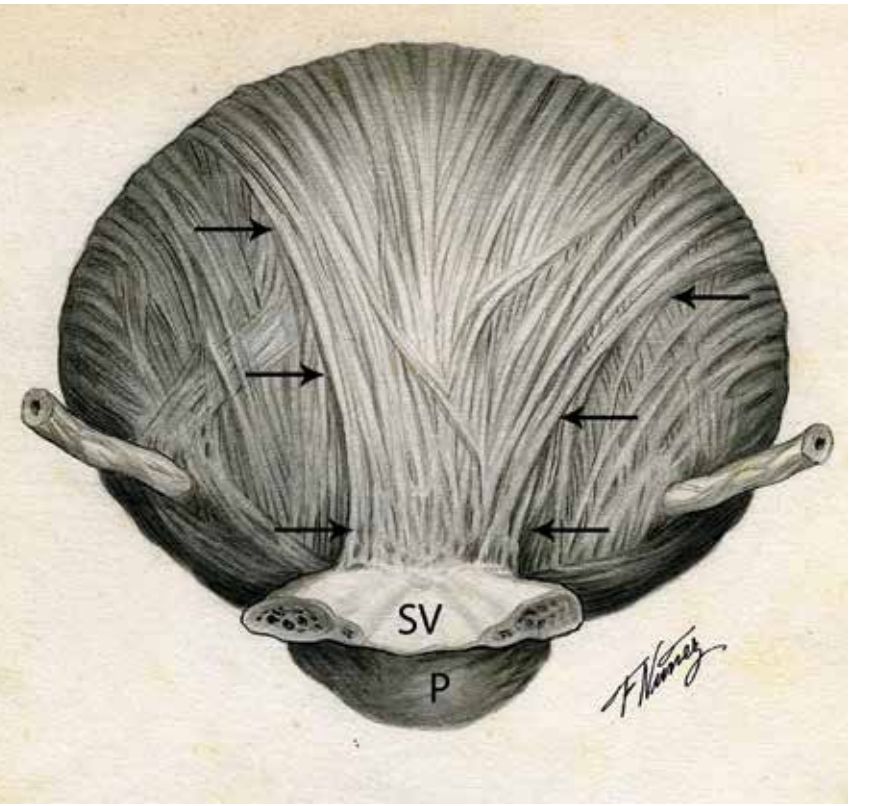

Figure 16: Posterior face of the bladder. Adult male. Posterior longitudinal fascia of the detrusor (arrowheads). Seminal vesicles (SV) and prostate (P). Adult male. Mixed media on paper, 23 x 21 cm. Artist: F. Nuñez, ca.1945.

INSTITUTO CAJAL

PASEO DE ATOCHA, 13

EL DIRECTOR

Madrid 5 de Octubre de 1925.

Amigo Gil Vernet:

Propone V. un tema dificil y sobre el cual solo conjeturas cabe exponer.

Desde luego anastomosis verdaderas no existen, quiero decir uniones substanciales entre axones de diversa procedencia.

Pero si no hay continuidad, existen como se sabe colaboraciones de axones de origen diferente en la constitucion de un nervio o filete nervioso anastomosado (plexos braquial, sacro-lumbar &). La hipotesis que yo formulé hace tiempo del isoneurotropismo, es decir que los cilindros ejes que llevan parecido camino se atraen para formar cordones mixtos, puede todavia defenderse sobretodo desde el punto de vista neurogénico (formación de las raices nerviosas, pares raquídeos &) Mas podrian entrar en juego otras influencias y mecanismos que por el pronto no se me ocurre puntualizar. En estos últimos años estan muy de moda para explicar la neurotización del cabo periferico de los nervios cortados las diferencias de potencial electricos entre los axones centrales y las vainas de Schwann del cabo periférico. Pero esto constituye una hipótesis que exige demostración.

Sabe le estima de veras su compañero y amigo.

S. Ramón y Cajal

Figure 17: Letter from Santiago Ramón y Cajal to Salvador Gil Vernet. 1925.

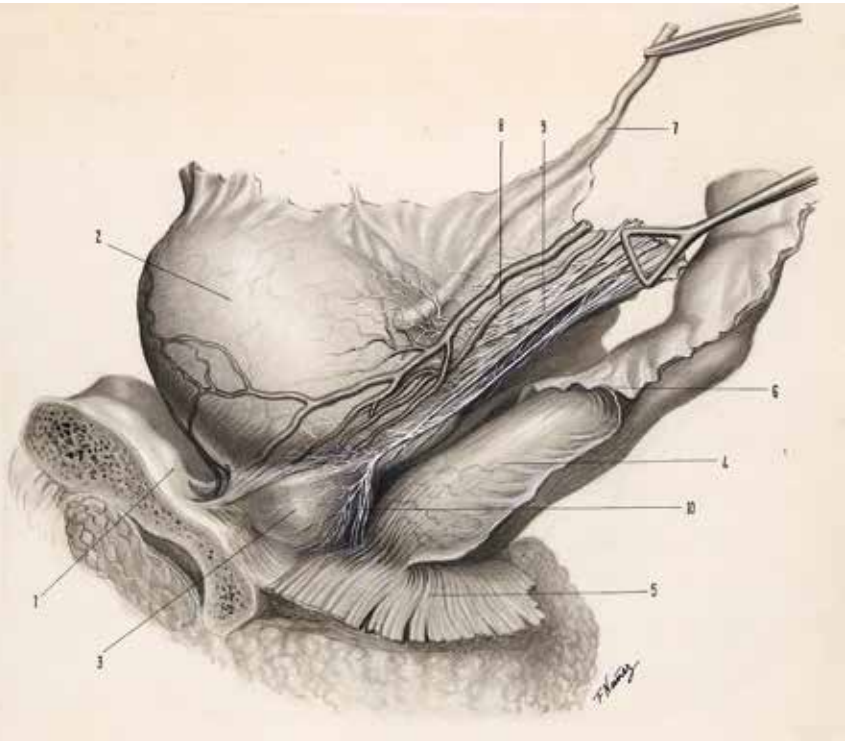

Figure 18: Left neural pelvic plexus. Adult male. Mixed media on paper, 28 x 31 cm. Artist: F. Nuñez, 1944.

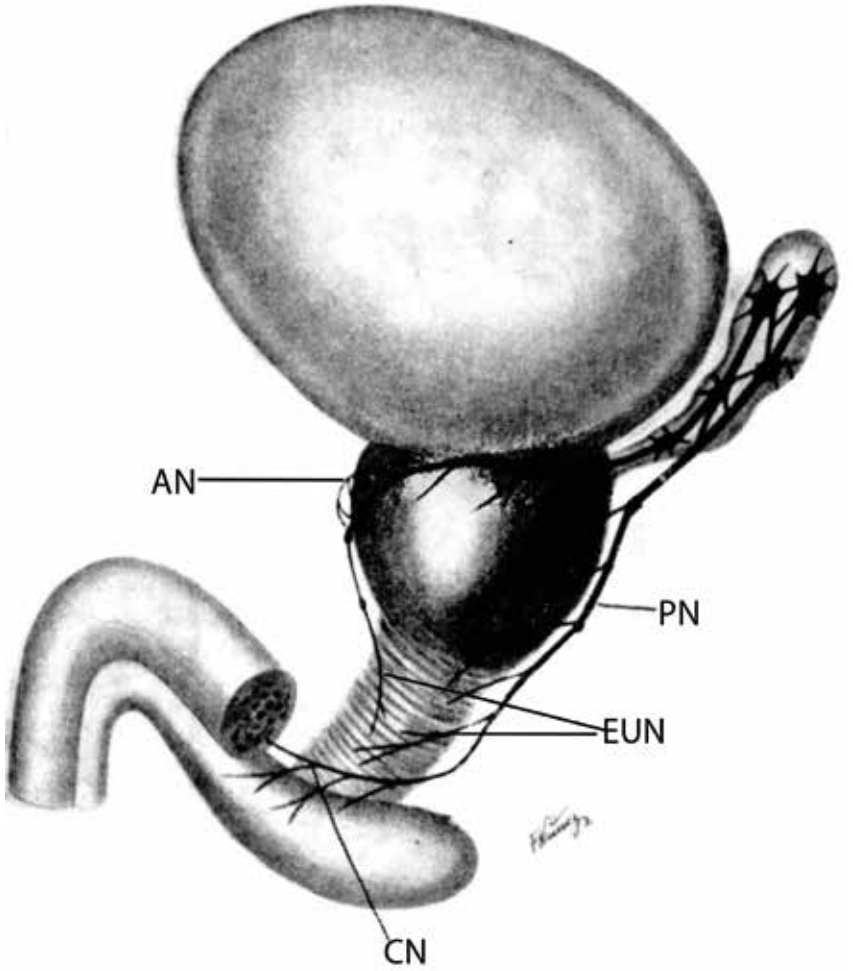

Figure 19: Diagram of the pelvic plexus in the male. Posterolateral view. Anterolateral nerves (AN). Posterolateral nerves (PN). External urethral sphincter nerves (EUN). Cavenous nerves and corpus spongiosum nerves (CN). 1964.

and inferior branches of the pelvic plexus along the ventral surface of the prostate was also corroborated many years later.[20]

In his studies on the membranous urethra and the external urethral sphincter, he described the presence of microscopic periurethral nerve ganglia and tiny nerve branches, a continuation of the pelvic plexus, which penetrate the mass of the external urethral sphincter. (Fig. 19) He thus assumed that autonomous nerves innervated the striated fibres of the urethral sphincter, contradicting the classical conception of the external urethral sphincter, only receiving somatic innervation through the internal pudendal nerve.

In addition, he assumed that some fibres of the internal pudendal nerve, following an intrapelvic pathway, joined the hypogastric ganglion very close to the entry of the pelvic nerves and innervated the striated urethral sphincter through the most caudal efferent branches of the pelvic plexus.[12] More than 50 years later, several authors confirmed in their publications this double innervation, i.e. somatic and autonomic, of the external urethral sphincter.[21, 22, 23, 24]

In his works on surgical technique, mainly those focusing on radical perineal prostatectomy, he highlighted the significant impact of preserving the nerves of the pelvic plexus on the incidence of postoperative urinary incontinence.[6]

Regional anatomy of the prostate

In 1953, Gil Vernet described the first regional anatomical model of the prostate gland. He clearly demonstrated that the prostate is not a homogeneous gland and that it consists of three regions: the cranial, the caudal and the intermediate glands.[10, 25] He wrote:

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20 Iwata, T et al. *Immunohistochemical studies on the distribution of nerve fibers in the human prostate with special reference to the anterior fibromuscular stroma.* Prostate. 2001, 48: 242-247.

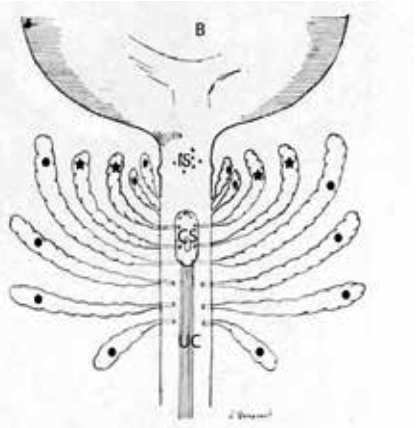
21 Narayan et al. *Neuroanatomy of the external urethral sphincter: implications for urinary continence preservation during radical prostate surgery.* J Urol. 1995, 153: 337-341.

22 Hollabaugh, R.S. Jr et al. *Neuroanatomy of the male rhabdosphincter.* Urology. 1997, 49:426-434.

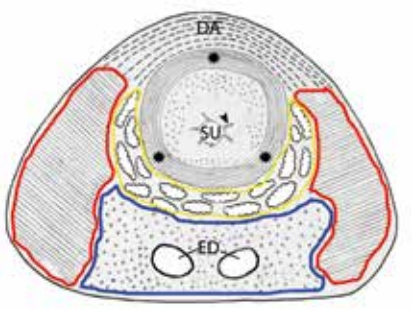
23 Arango, O, Doménech, J.M. *Anatomic and clinical evidence of intrapelvic pudendal nerve and its relation with striated sphincter of the urethra.* Actas Urol Esp. 2000, 24: 248-254.

24 Carlson, K.V., Nitti V.W. *Prevention and management of incontinence following radical prostatectomy.* Urol Clin North Am. 2001, 28: 595-612.

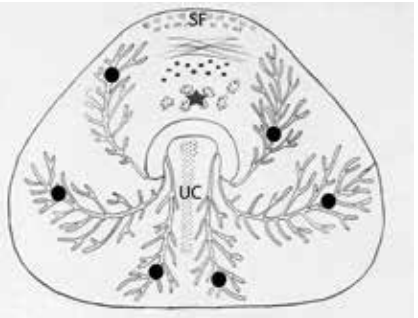
25 Gil Vernet, S. *"Anatomie et physiologie de la prostate. Physiologie de la prostate et des vésicules seminals".* Enciclopédie Médico-Chirurgicale. 1975, 18500: 1-10.



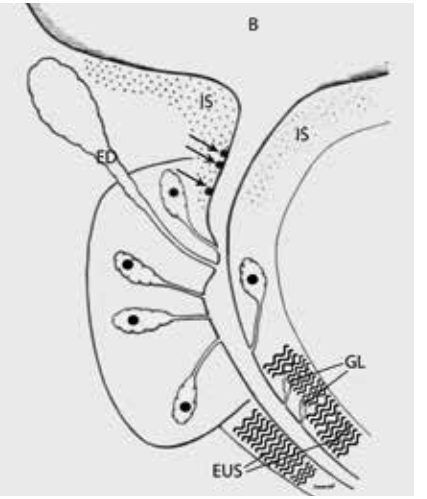
A. Coronal section.
Bladder (B), urethral crest (UC), colliculus seminalis (CS). Cranial gland with intrasphincteric (IS) and subsphincteric glands (asterisk). Intermediate gland acini (stars). Caudal gland acini (filled circle)



B. Transverse section (supracollicular level). Supracollicular urethra (SU). Internal vesical sphincter (asterisks). Intrasphincteric gland (arrowhead). Cranial gland with subsphincteric acini (yellow). Intermediate gland (blue) and caudal gland (red)



C. Transverse section (infradollicular level). External urethral sphincter (SF). Posterolateral (filled circles) and anterior acini (star) of the caudal gland



D. Medial sagittal section.
Ejaculatory duct (ED). Internal vesical sphincter (IS), Little glands. External urethral sphincter (EUS). Cranial gland with intrasphincteric (arrows) and subsphincteric (asterisk) acini. Caudal gland acini (filled circles).

Figure 20: Prostate regional model of Gil Vernet. Diagram.

> *"…accepting the principle of duality of the prostate gland as valid, we believe that a detailed analysis of these complex problems will not unequivocally support the conclusive division between the cranial gland and the caudal gland. It is necessary to insert a portion between both poles, which we shall call the intermediate gland, establishing a smooth transition between the cranial and caudal portions."*[12]

This model was urethrocentric, with areas defined according to the location of their collecting ducts opening into the urethra (Fig. 20) and was later used by McNeal, with very small variations, as the foundation of his zonal anatomy model.[26, 27, 28] The cranial gland is formed by intrasphincteric glands, located within the internal vesical sphincter (Albarran's periurethral glands), and two subsphincteric lateral lobes, which correspond to the transition zone in McNeal's model.

The caudal gland is formed by the posterolateral and apical (dorsal and ventral) surfaces of the prostate, the collecting ducts of which open distally beyond colliculus seminalis, on both sides of the urethral crest. This region is identical to the area described as the peripheral gland in McNeal's model, although this author ignored the glands located on the ventral apical surfaces of the gland, in what he called the anterior fibromuscular stroma. The collecting ducts of the intermediate gland drain into the colliculus seminalis at the opening of the ejaculatory ducts. The glandular acini are located dorsolaterally to the pathway of the ejaculatory ducts forming the craniodorsal surface of the prostate. This intermediate gland is identical to McNeal's central zone.

In Gil Vernet's embryological studies the caudal gland is induced by the urogenital sinus mesenchyma. The cranial and intermediate glands are induced by an area of mesenchyma, which consists of the fusion of the Wolffian and urogenital sinus mesenchyma.

26 McNeal, J.E. *Regional morphology and pathology of the prostate.* Am J Clin Pathol. 1968, 49: 347-357.
27 Villers, A. et al. *Anatomy of the prostate: review of the different models.* Eur Urol. 1991, 20: 261-268.
28 Timms, B.G. *Prostate development: a historical perspective. Differentiation.* 2008, 76: 565-577.

Gil Vernet observed that benign hyperplasia develops in the cranial gland and that carcinoma develops in the caudal gland. Prof. Charles B. Huggins cited this major work: *"The Gil Vernet Phenomenon wherein the human prostate is separated into two physiologically and oncologically different divisions, is of permanent value. It is a wonderful discovery"*.[29]

Conclusions

Salvador Gil Vernet combined a keen interest in morphological sciences from an early age, a passion for urology and an enormous capacity for working. This allowed him to spend endless hours behind the microscope and in the dissecting room. His first observations concerning the urological anatomy of both embryo and adult did not correspond with the concepts described in traditional works. This led him to question whether past thinking was, in fact, true, and to try and find *ab initio*, based on his own experience, what the true anatomy of the pelvis and the perineum really was.

Through the histotopographic technique, he managed to achieve a perfect microscopic dissection, which allowed him to unravel the innermost secrets of topographic anatomy, and apply this knowledge as an urologist to attain better understanding of urogenital physiology and pathology, and develop more effective surgical techniques, ultimately opening the doors to scientific urology. In his own words:

> *"Precise, almost mathematical, knowledge of anatomy is a highly fertile source of surgical applications, suggesting new techniques and helping to perfect and simplify existing surgical methods, making them less mutilating and more benign and, in short, raising surgery to the rank of true science."*[8]

After Salvador Gil Vernet's retirement, his son, Jose María Gil-Vernet Vila, professor of urology and a worthy disciple of his father, took over and upheld the urology department's prestigious reputation, becoming a pioneer in kidney and pancreas transplants in Spain and in the invention and development of new surgical techniques in urology, but that's quite another story.

29 Letter from Prof. Charles B. Huggins on August 13, 1963.