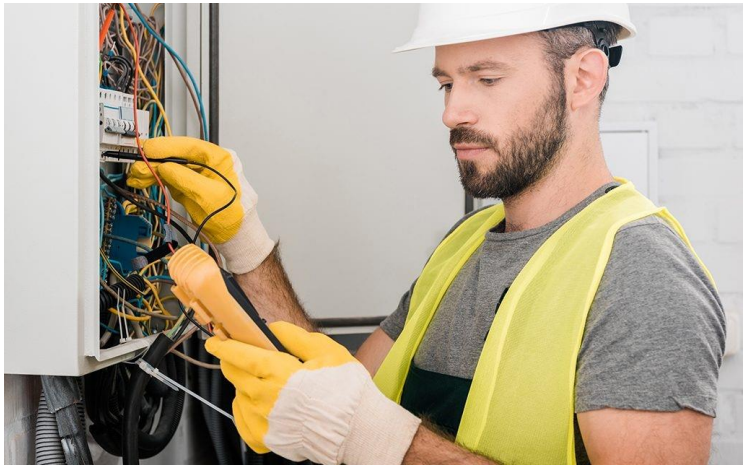
The use of electricity in Urology



Philip E.V. Van Kerrebroeck, MD, PhD, MMSc

Prof. em. of Urology, Maastricht University (Nl)

Homo sapiens sapiens and urologist, Antwerp, Belgium

Disclosures

LECTURER:

Astellas, Axonics, Ferring, Medtronic

CONSULTANT:

Asieris, Muvon, Neuspera, Saluda, SmartWeave

BOARD MEMBER:

EAU (History Office, Policy Office), ICS (Standardisation Committee), Museum Lambotte (History of Medicine), Dutch Society for Tribal Art & Culture

Disclosures bis

The use of electricty: from electric fish to urinary neuromodulation

The use of natural electricity

Production of artificial electricity

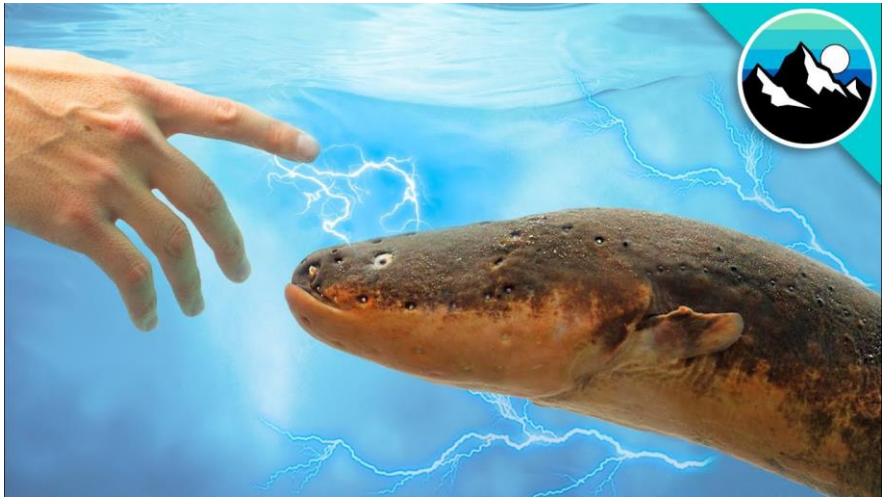
The use of electricity in Medicine

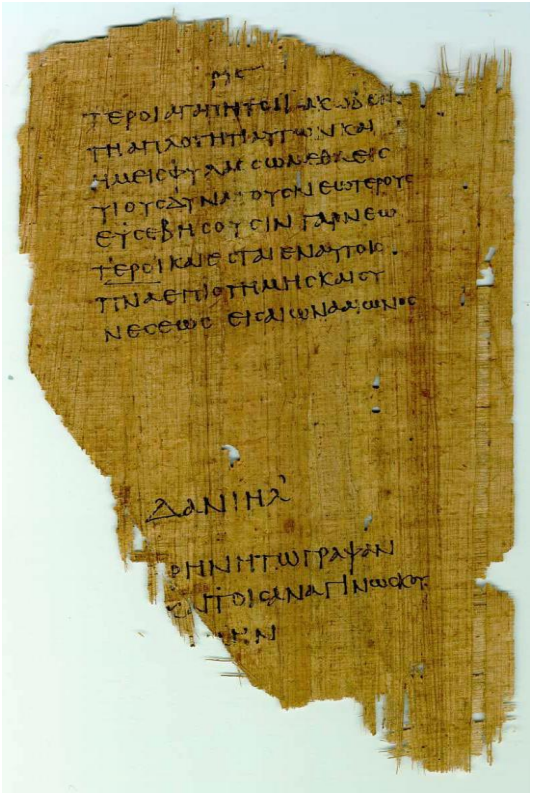
The use of electricity in Urology

Ancient Egypt

Natural electricity (torpedo fish, friction)

Chester - Beatty manuscript (1570 BC)

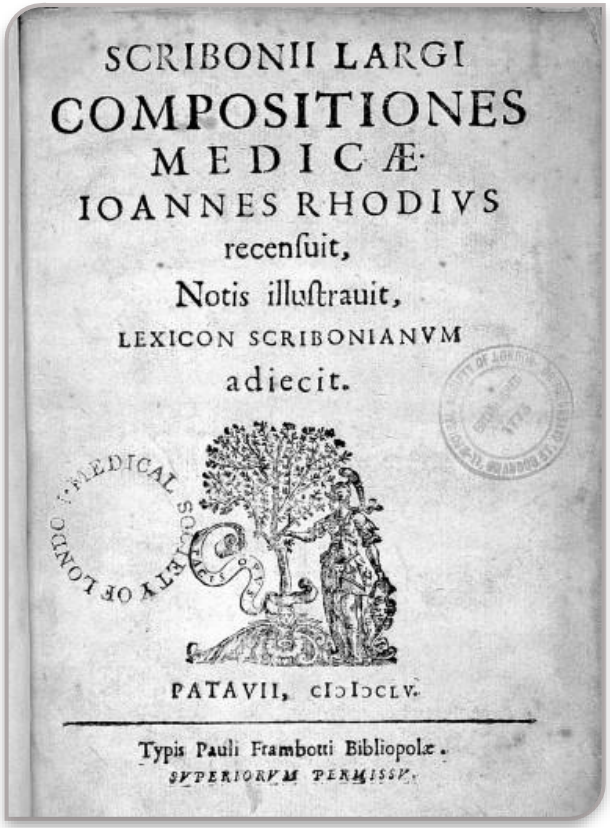




Ancient Rome

Scribonius Largus (ca. 47 AD)

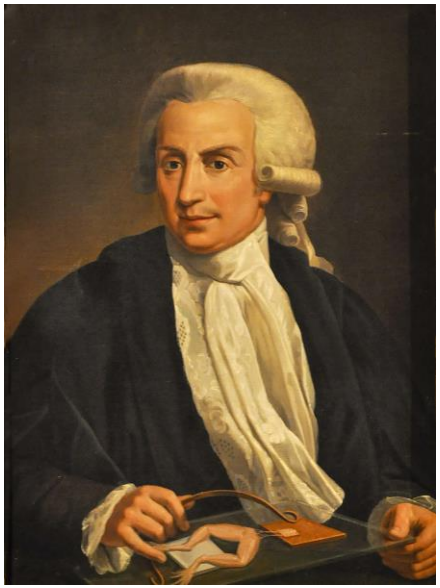
Compositiones

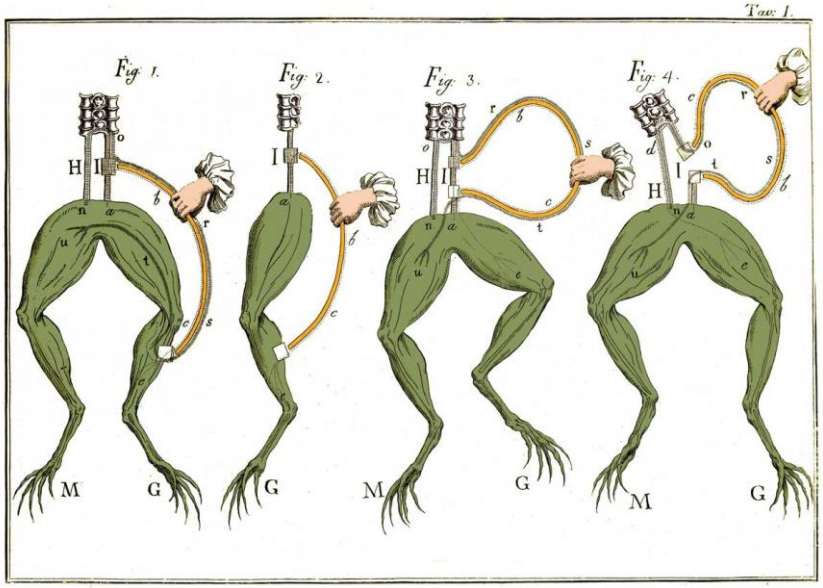


Luigi Galvani (1737-1798)

Frog leg experiments (1791)

Relation current and muscle contraction

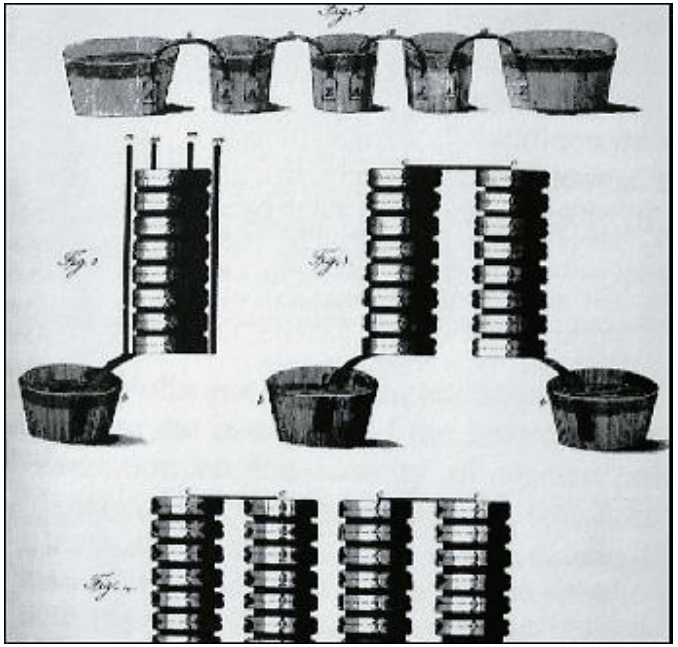


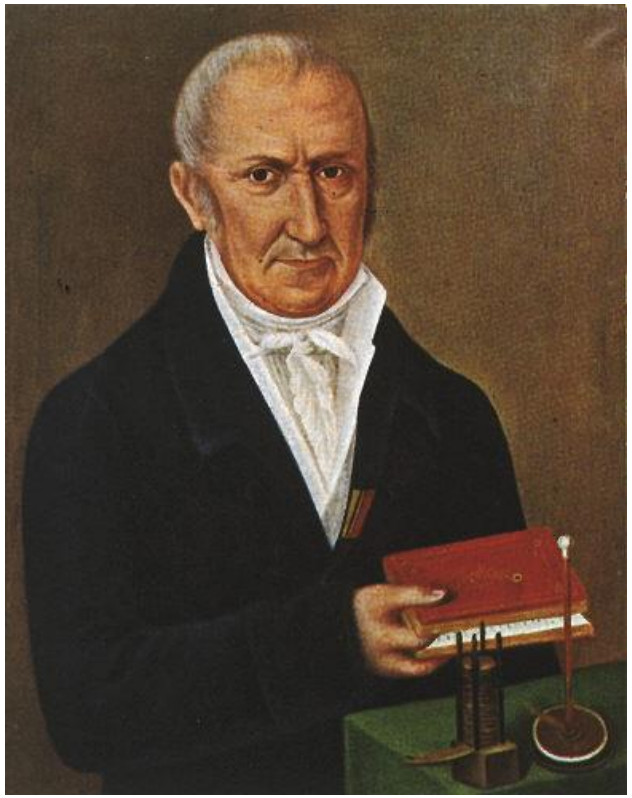


Alessandro Volta (1745- 1827)

Electric battery

Nerve stimulation





Hans Christian Oersted (1777-1851)

Elektricity and magnetism

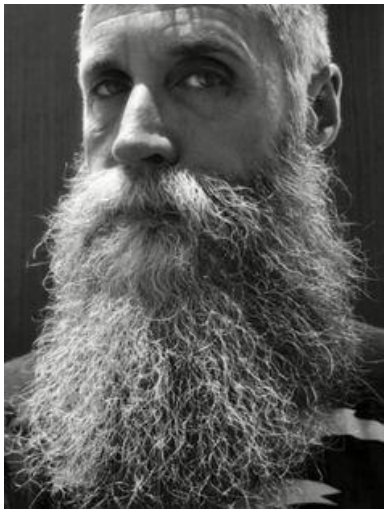
“Current” (1820)

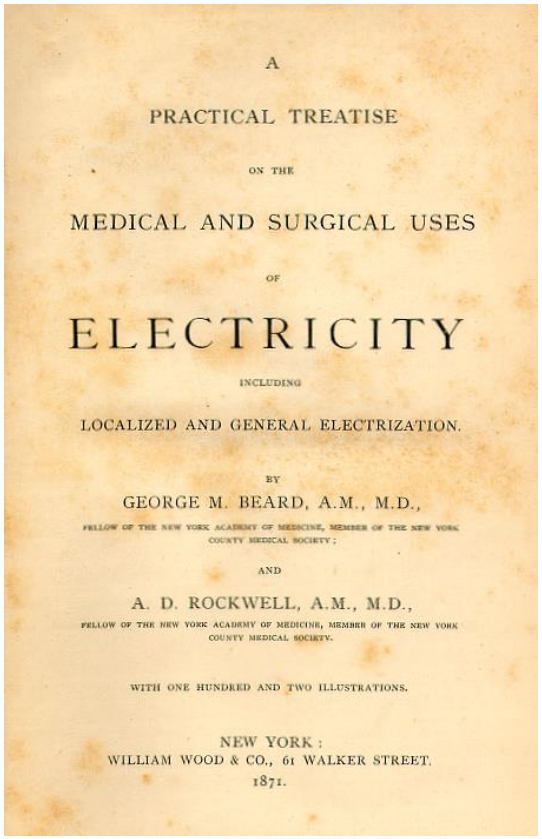
Guillaume Duchenne (1806-1875)

Muscle stimulation with induction (1855)

Study of functional muscle anatomy

1871:
George Beard (1839-1883) and Alphonso Rockwell (1840-1925)





Mathias Saxtorph (1822-1900)

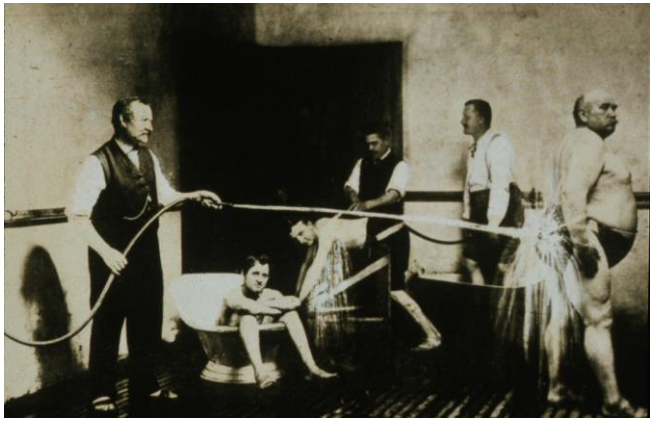
Intravesical (bladder) stimulation for urinary retention

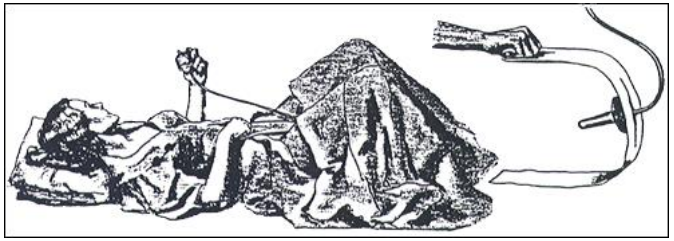
Transurethral catheter (1878)

Intravaginal, intrarectal and skin patch stimulation

From physical therapy over physiotherapy to elecrotherapy:

- Hydrotherapy (cold water showers, vaginal douches, aromatic baths)
- Arnold Kegel (1894-1972): functional reeducation of the pelvic floor (1948)
- Kelvin Caldwell (1938-1973): intravaginal electrostimulation (1963)

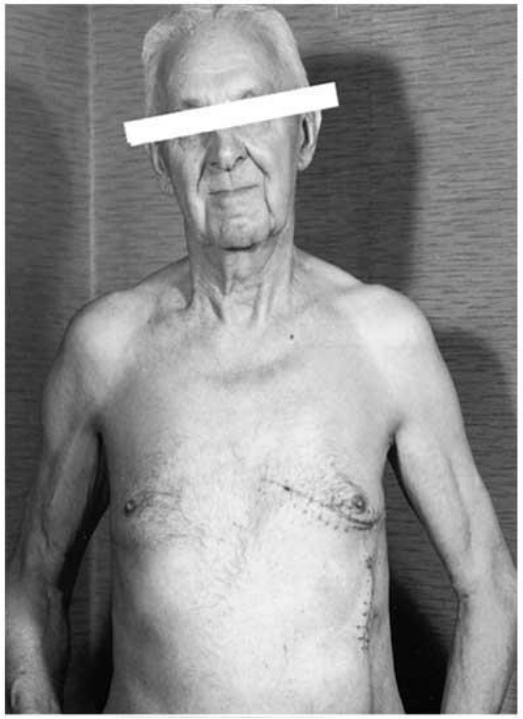




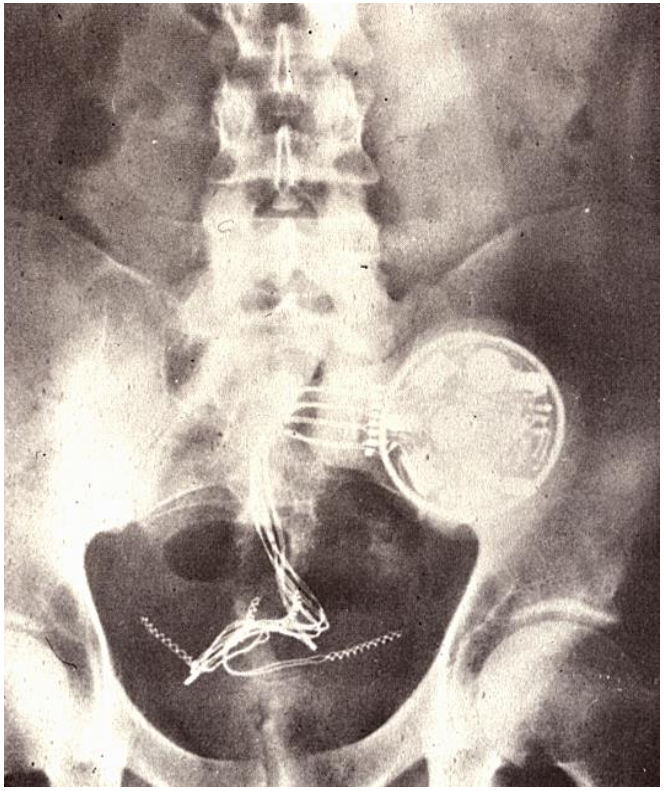
Leon Chaffee (1885-1975) and Richard Light (1902-1994)

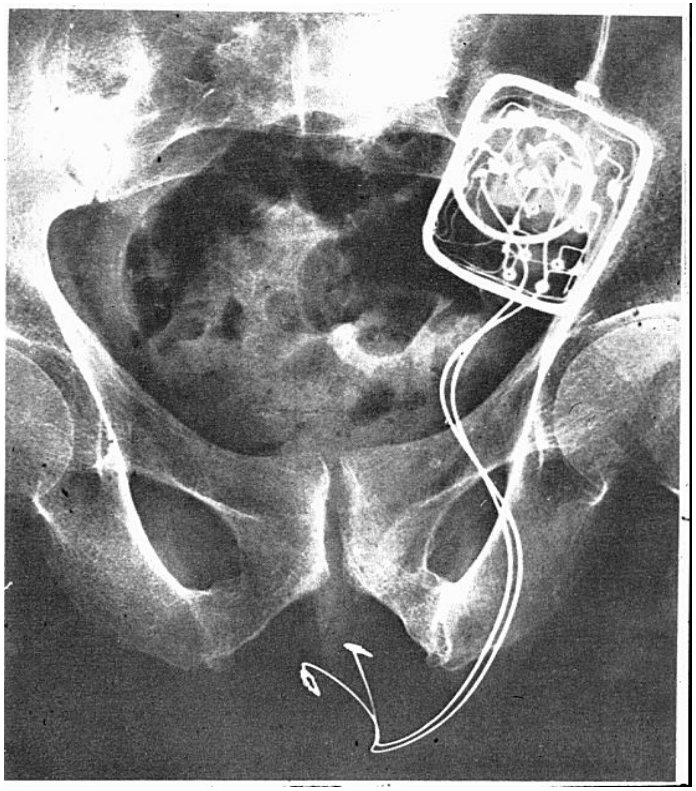
Nerve stimulation (Harvard, 1934)

Implant and transcutaneous magnetic induction



Kelvin Caldwell (1921-1978): direct stimulation (bladder + urethral sphincter), 1950-1960



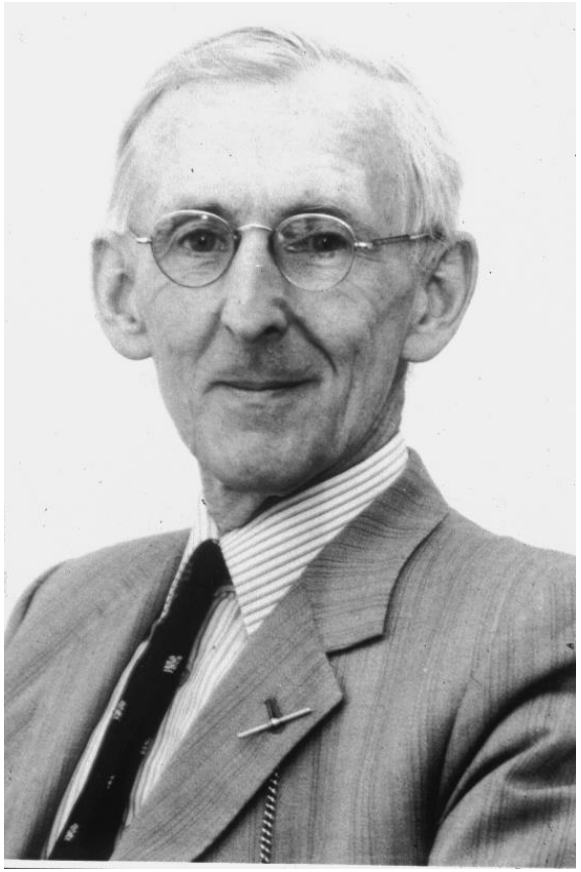


From neurostimulation to neuromodulation

- Robert Ultzmann (1842-1898): electrical bladder stimulation (1890)
- Theodor Burghele (1905-1977): pelvic nerve stimulation for voiding (1955)
- Giles Brindley (1926): bladder stimulation in spinal cord injury (1976)
- Emil Tanagho (1932): sacral nerve stimulation for LUTD (1976)

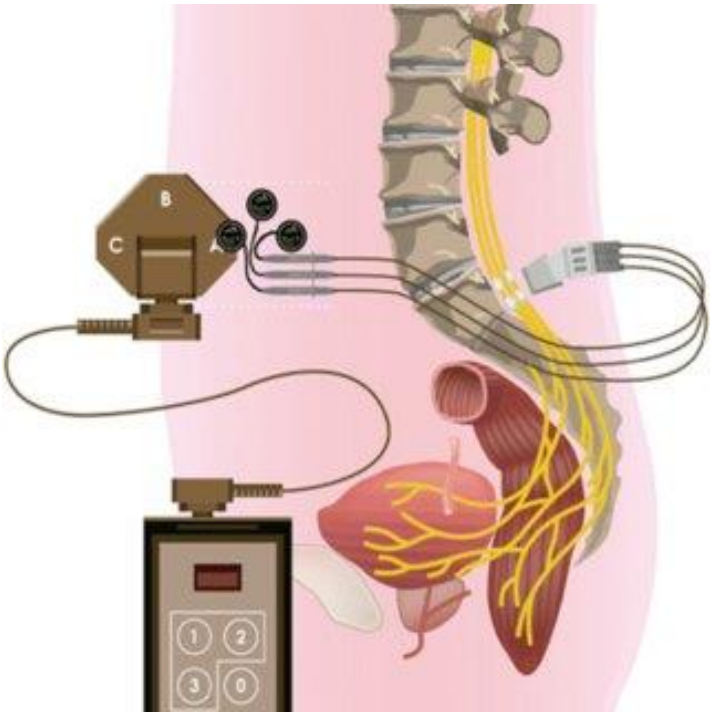
1978-1979: Emil Tanagho – Giles Brindley

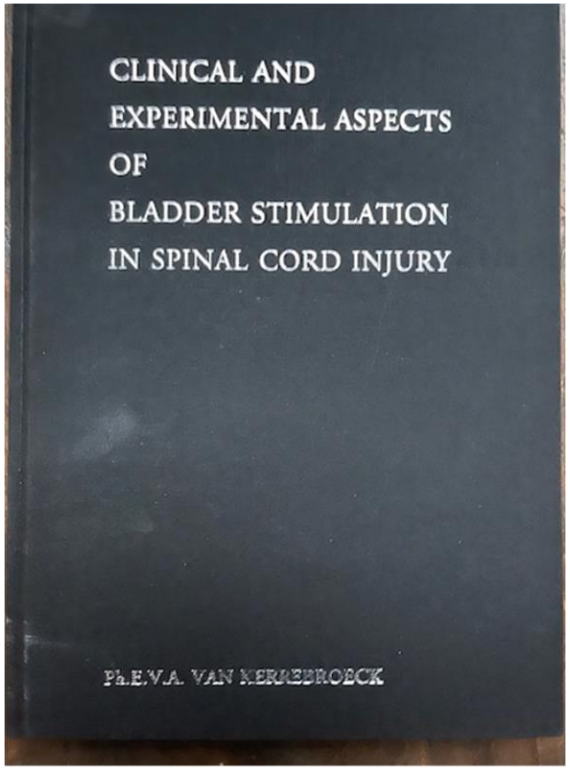
Emil Tanagho (1932-2024)



Giles Brindley (°1926)

Sacral deafferentation and Intradural Anterior Sacral Root Stimulation (SARS, Brindley, 1969-1977/1976)





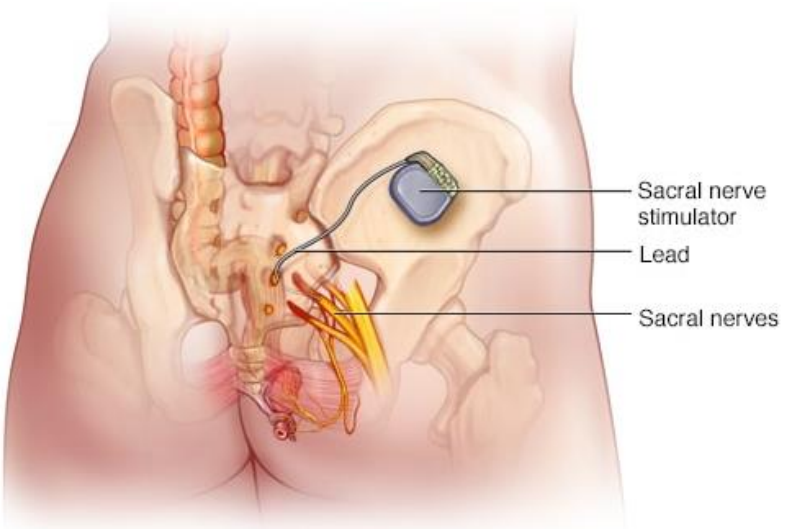
Nerve Stimulation --> neuromodulation

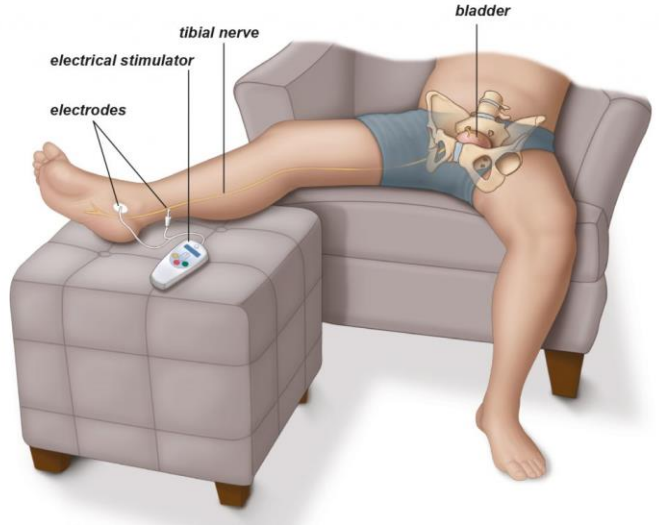
Sacral nerve stimulation (SNS) / Sacral Nerve Neuromodulation (SNM):

- Europe, 1994
- USA, 1994-1997

Percutaneous Tibial Nerve Stimulation (PTNS):

- Mc Guire, 1983
- Stoller, 1999



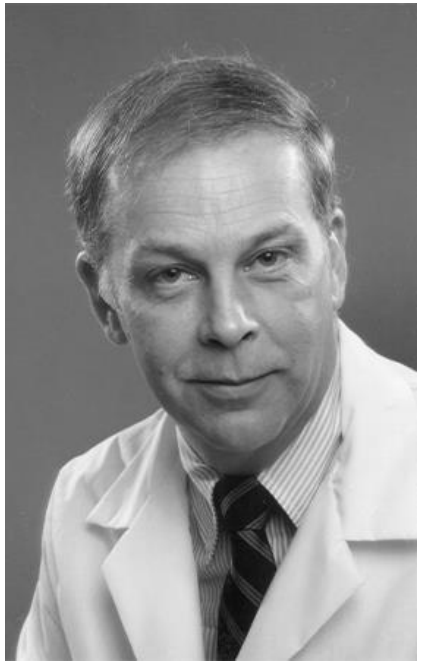


PTNS

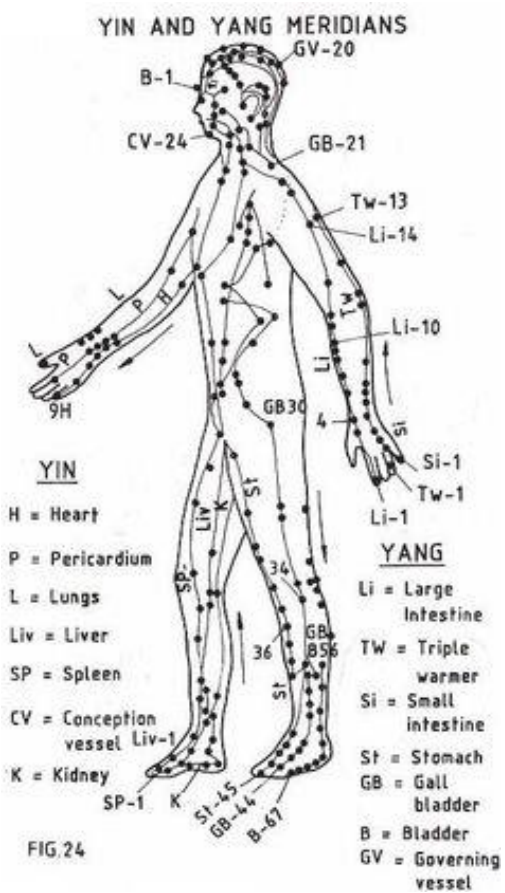
1983: Edward Mc Guire (1940-2021)

1999: Michael Stoller (°1951)

3000 BC: ? (????-????)



Neuromodulation with acupuncture



Energetic harmony of the urogenital tract

3000 BC: acupuncture (China)

San Yin Jiao point (spleen 6), medial side lower leg

Meeting point of 3 yin channels (spleen, liver, kidney)

6-8 cm cephalad of the median malleolus (posterior tibial nerve)

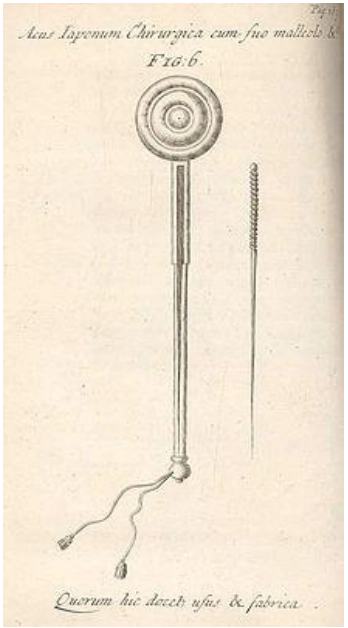
Neuromodulation with acupuncture for urinary problems

Wilhelmus ten Rhijne (1647-1700)

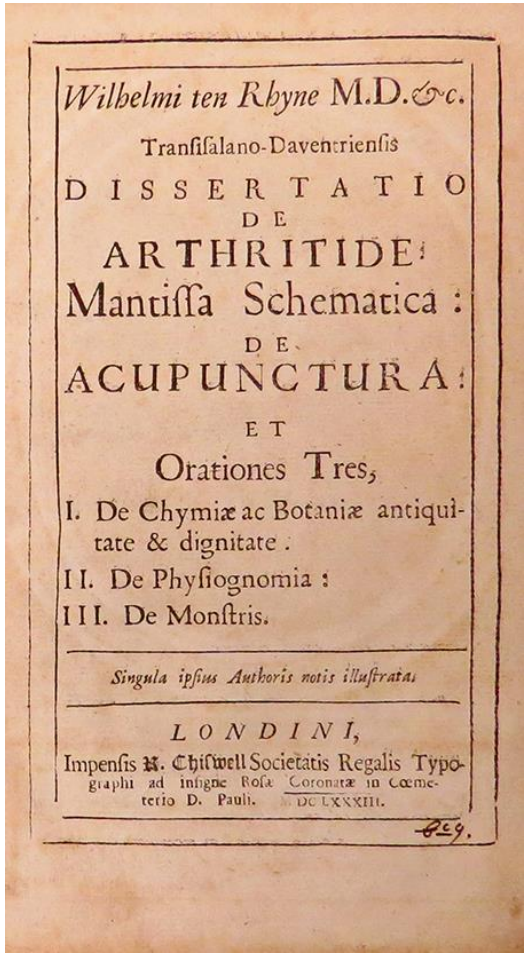
Physician with the VOC

1674: contact with traditional medicine (including needle therapy)in China

Discovers the use of needles for the treatment of urinary problems



Acupuncture and Western medicine



Wilhelmi ten Rhyne M.D. &c.

Transisalano-Daventriensis

DISSERTATIO
DE
ARTHRITIDE:
Mantissa Schematica:
DE
ACUPUNCTURA:
ET
Orationes Tres,

I. De Chymiæ ac Botaniæ antiquitate & dignitate.
II. De Physiognomia:
III. De Monstris.

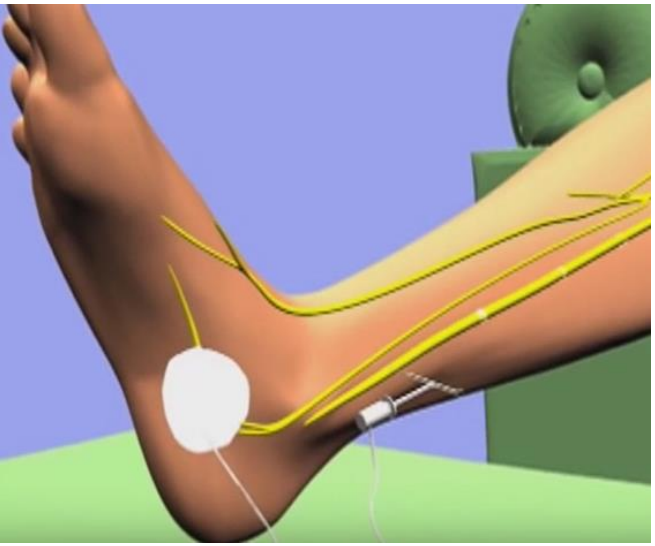
Singula ipsius Authoris notis illustrata.

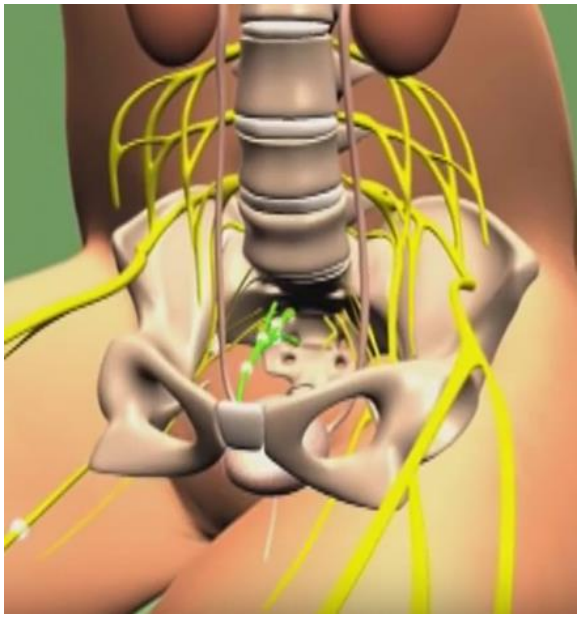
LONDINI,
Impensis R. Chiswell Societatis Regalis Typographi ad insigne Rosæ Coronatæ in Cœmeterio D. Pauli. DC LXXXIII.

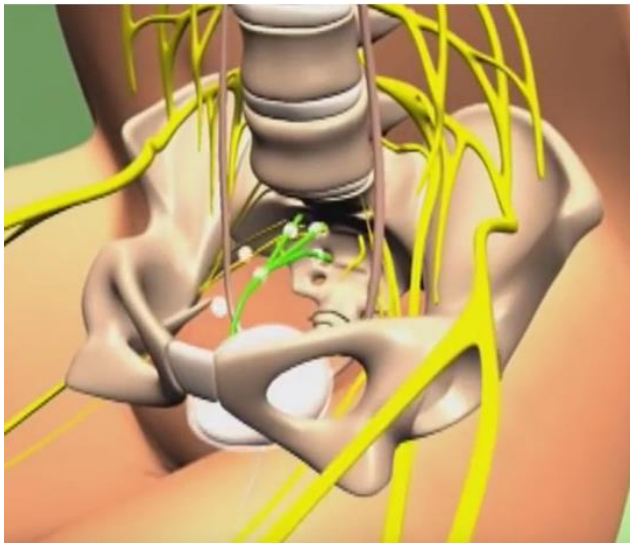
1683: Wilhelmus ten Rhyne, Dissertatio de Arthritide: Mantissa Schematica: de Acupunctura et Oriationes Tres,

- Describes the use of needles in medicine ‘apunctura’
- First publication in the West abaout acupuncture
- Promotes the use of acupuncture in Western medicine

PTNS : FDA approval October 8, 2010)





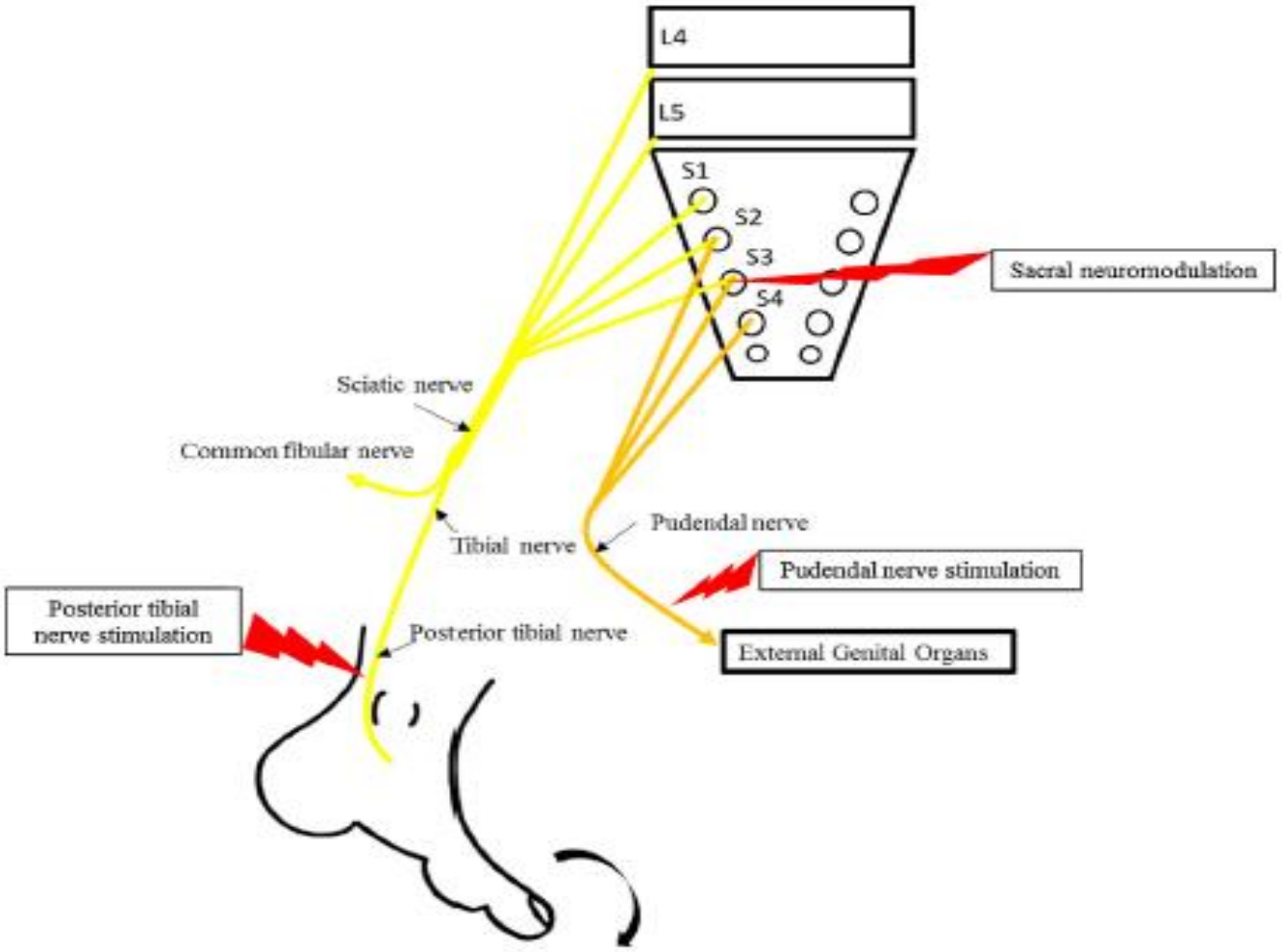


Sacral Nerve Neuromodulation (SNM)

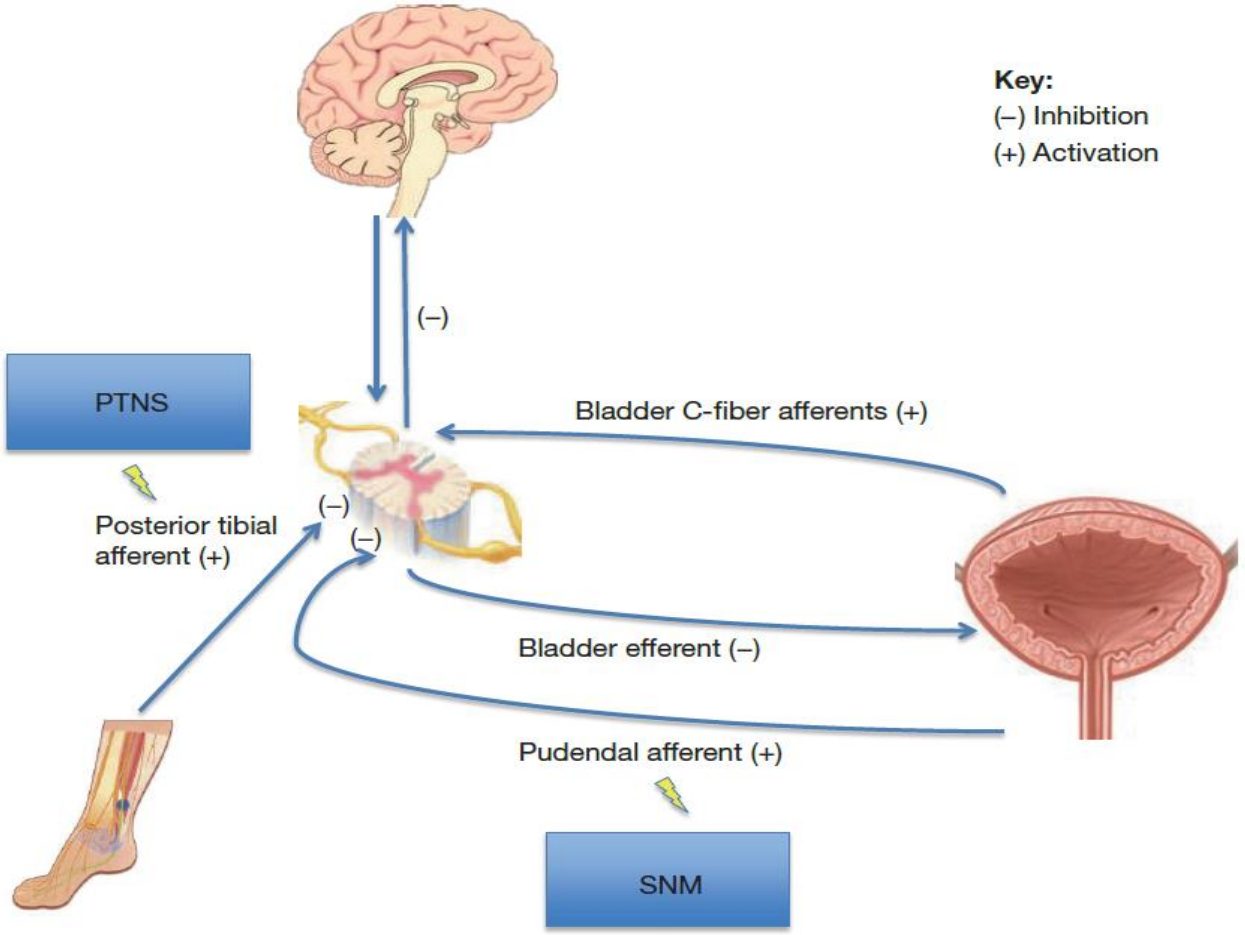
1994: Europe

1994-1997: USA

Neuromodulation for LUTD: anatomical sites



Neuromodulation for LUTD: working mechanisms



Tibial Nerve Stimulation for OAB: standard methods

Percutaneous Tibial Nerve Stimulation (PTNS)

- intermittent temporary stimulation

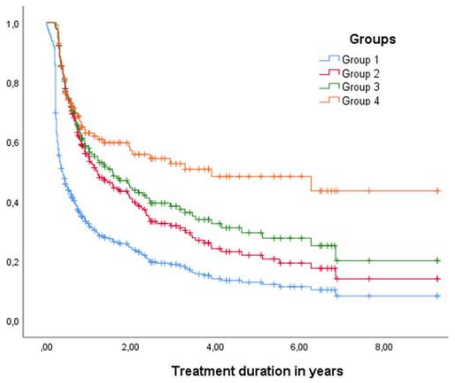
- needle or patch

- usually 12 initial, weekly office visits (30 min.)

- most patients need monthly visits to maintain the improvements

- usually takes 5-7 weeks for a change in bladder control

- High relapse rate after stopping PTNS therapy



Peters KM. et al. Randomized trial of percutaneous tibial nerve stimulation versus Sham efficacy in the treatment of overactive bladder syndrome: results from the SUmiT trial. J Urol . 2010 Apr;183(4):1438-43.

Sacral neuromodulation for LUTD: standard methods

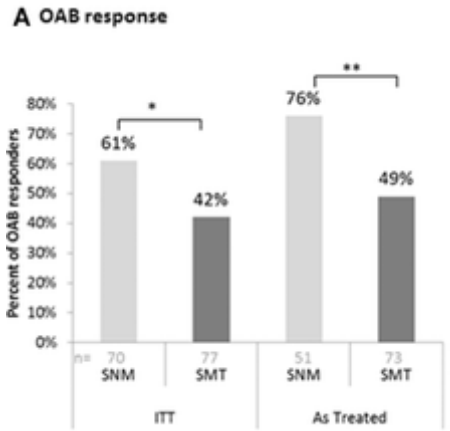
Sacral Nerve Stimulation (SNM)

- > 30 years of experience and follow-up
  (Interstim systems, Medtronic)

- > 425.000 patients implanted worldwide
  (urinary and faecal)

- recharge-free and rechargeable systems
  (Medtronic and Axonics)

- long term efficacy and safety data



Van Kerrebroeck PhEV et al. Results of sacral neuromodulation therapy for urinary voiding dysfunction: outcomes of a prospective, worldwide clinical study. J Urol 2007 Nov;178(5):2029-34.

New technology and techniques for sacral neuromodulation

Full body MRI safe stimulation leads (1.5 and 3 T)

- more patients can be treated

- less explants

Rechargeable batteries

- less frequent need for battery replacement

New recharge-free batteries

- longer longevity

Smaller batteries (rechargeable)

- greater patient comfort

Better electrode implantation technique

- lower amplitude stimulation at multiple contact points

- increased recharge-free battery life or reduced recharging + more programming possibilities

K Matzel, E Chartier-Kastler, C Knowles, P Lehur, A Muñoz-Duyos, M Sørensen, Ph Van Kerrebroeck, S De Wachter
Sacral Neuromodulation: Standardized Electrode Placement Technique. Neuromodulation, 2017, vol 20;8, 816-824.

New technology for Sacral Nerve Modulation

r-SNM System™ (Axonics, Irvine)

- rechargeable battery

- small battery (5.5 cm3)

- full body MRI safe

InterStim™ Micro Neurostimulator and SureScan™ Lead (Medtronic, Minn)

- rechargeable battery

- small battery (2.8 cm3)

- full body MRI safe

Updated technology for Sacral Nerve Modulation

Medtronic InterStim X IPG (02/2022)

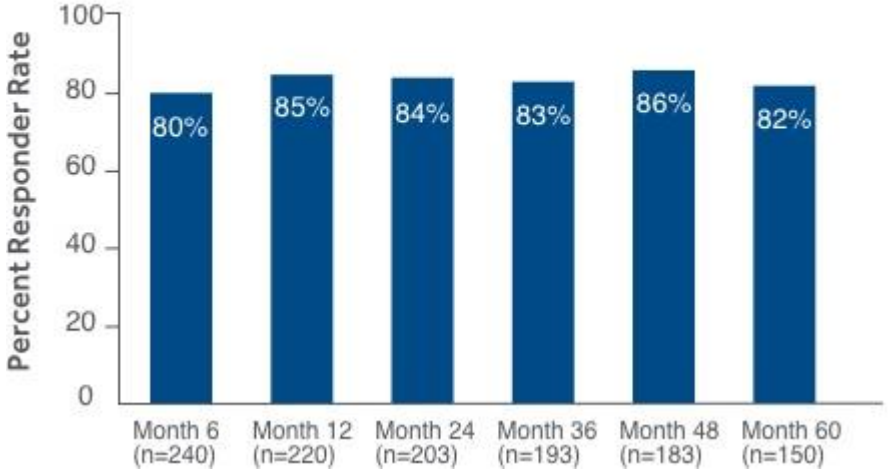
- recharge-free battery
- battery lasting up to 15 years
- full body MRI safe

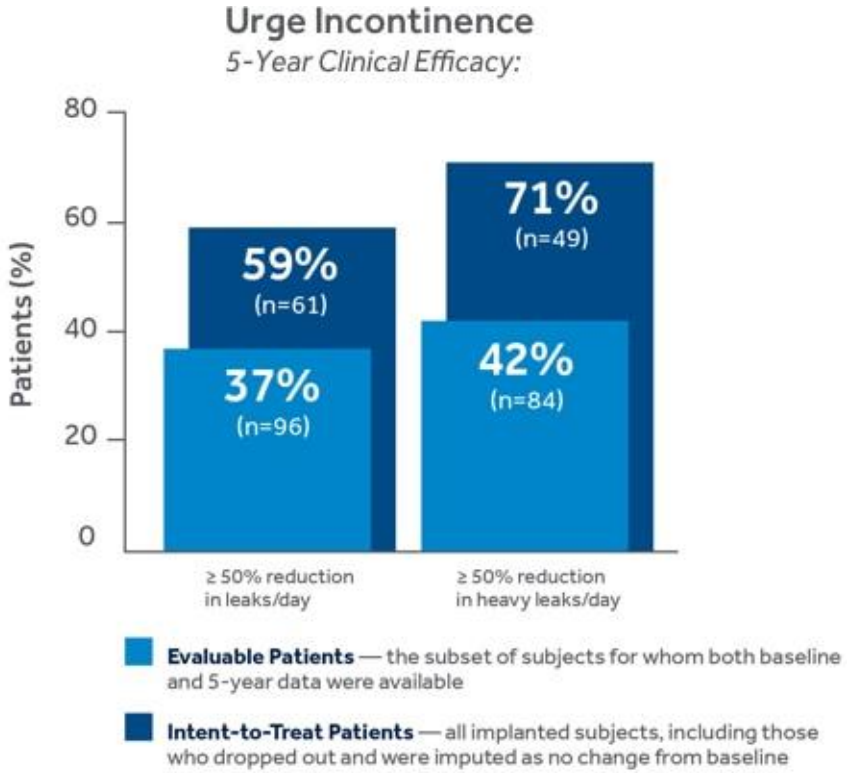
The Axonics F15 IPG (03/2022)

- recharge-free battery
- full body MRI safe

InterStim™ Neurostimulator and SureScan™ Lead (Medtronic, Minneapolis): results

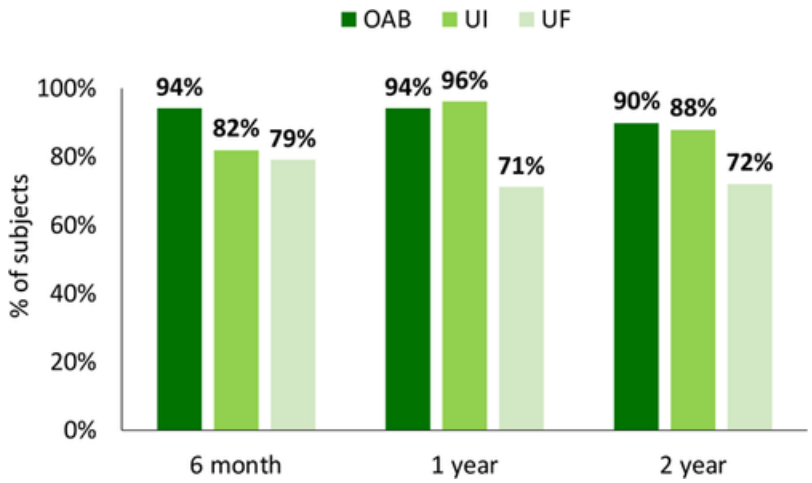
SNM Results Sustained at 5 Years[1,3]

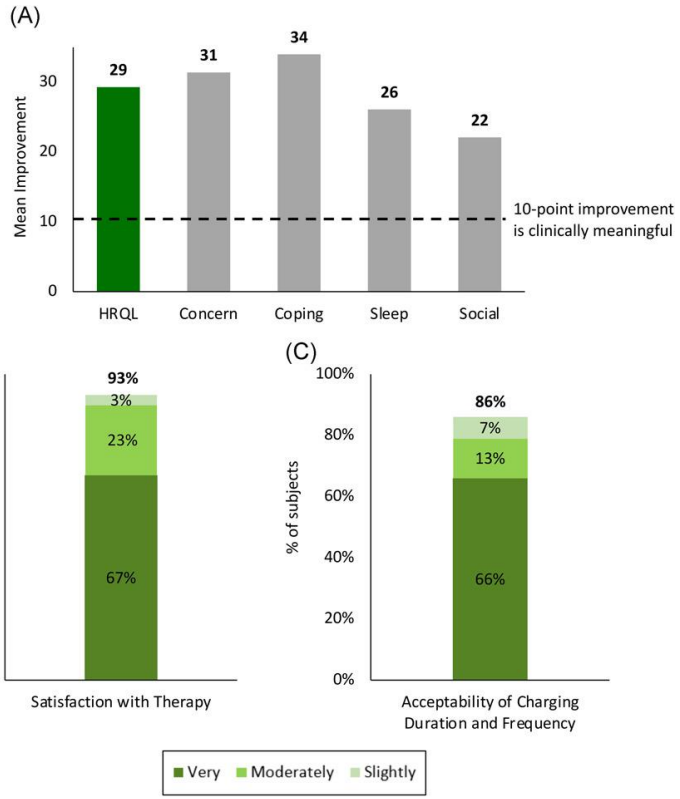


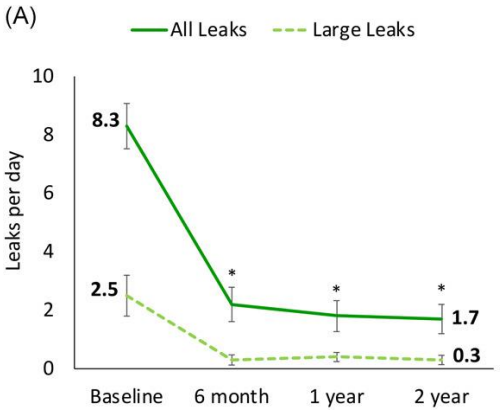


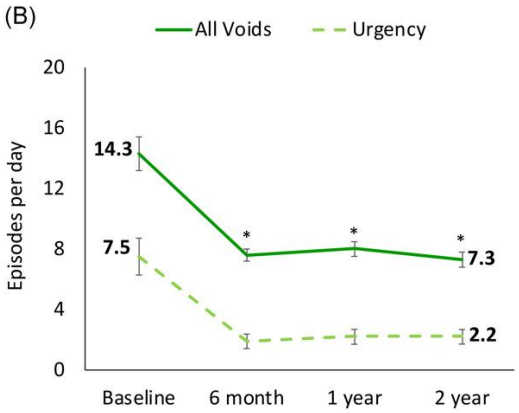
Siegel S, Noblett K, Mangel J, et al. Five-year follow-up results of a prospective, multicenter study of patients with overactive bladder treated with sacral neuromodulation. J Urol 2018;199(1), 229–236.

Rechargeable r-SNM System™ (Axonics, Irvine): results



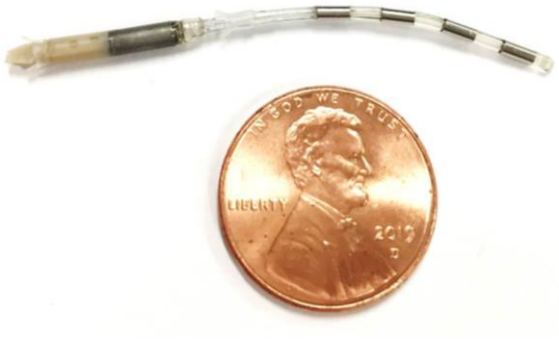






B Blok, Ph Van Kerrebroeck, S De Wachter , A Ruffion, F Van der Aa, MA Perrouin-Verbe, S Elneil; Two-year safety and efficacy outcomes for the treatment of overactive bladder using a long-lived rechargeable sacral neuromodulation system, Neurourol & Urodyn. 2020;1–7.

Experimental (non-FDA approved) technology for Sacral Nerve Modulation



AHLLevees System (Neuspera Inc, San Jose)

- miniature implanted stimulator incorporated with the electrode for the sacral foramen

- external wireless mid-field powering unit

- no implanted pulse generator

- first in human implant performed in 2018

- actually in clinical trial

Van Kerrebroeck P, Reekmans M, van Koeveringe GA, et al. First in human implantation of a mid-field powered neurotimulator at the sacral nerve: results form an acute study. Neurourol Urodyn. 2019;38(6):1669-1675.

Experimental implantable devices for Tibial Nerve Stimulation

Renova iStim™ system (BlueWind Medical, Herzliya, Israel)

- leadless implant, open procedure

eCoin system (Valencia Technologies, Ca)

- open procedure

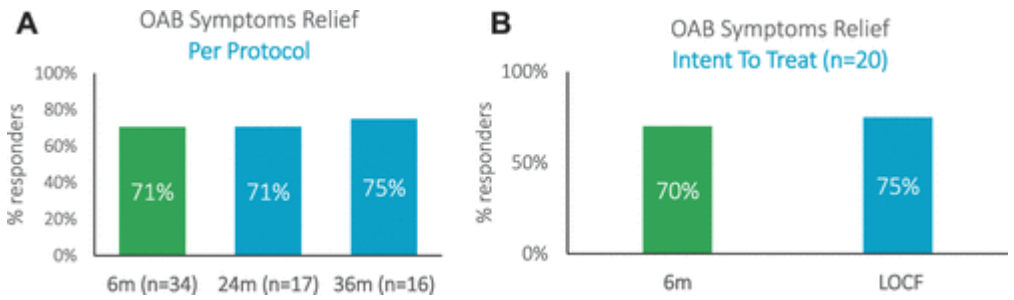
StimRouter (Bioness, Ca)

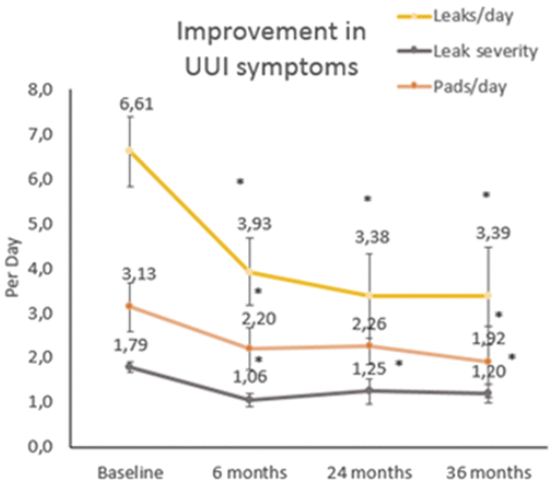
- antegrade percutaneous implantation

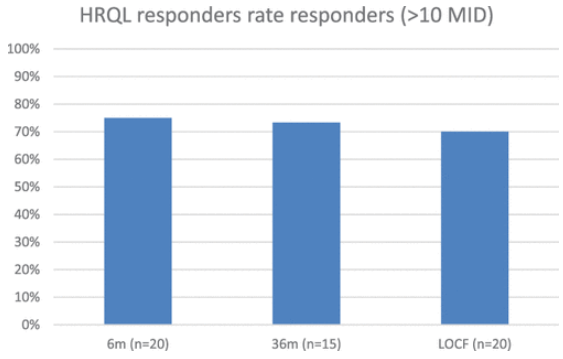
Protect PNS (Micron MC, Stimguard LLC, UroMedical Corp, Fl)

- retrograde percutaneous implantation

Renova iStim™ system (BlueWind Medical, Herzliya, Israel)







M te Dorsthorst, G Digesu, V Tailor, M Gore, Ph Van Kerrebroeck, H van Breda, S Elneil, J Heesakkers 3-Year Follow-up of a New Implantable Tibial Nerve Stimulator for the Treatment of Overactive Bladder Syndrome J Urol Adult Urology 1 Sep 2020.

The future of neuromodulation for Lower Urinary Tract Symptoms

Technical innovations

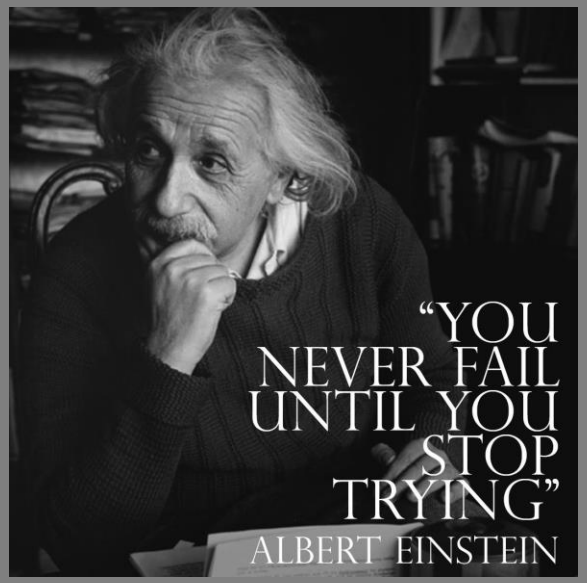
- improved battery technology
- external power sources
- implantable tibial/pudendal nerve implants
- non-invasive leads and

Shared decision-making process

- different choices (anatomical, technological)
- specific algorithms to be developed (personalized approach)

New surgical and stimulation techniques

- one stage implantation and conditional stimulation
- additional target nerves (combination?)



Thank you 4 ur attention!

Be safe, well and healthy!