NEUROMODULATION
THE AUTONOMIC NERVOUS SYSTEM AND GASTROINTESTINAL TRACT DISORDERS

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PURDUE UNIVERSITY
**MULTIPLE REFRACTORY GI DISORDERS EXIST.**

**VISCERAL ATLASES OF THE GI TRACT ARE AVAILABLE.**

**REMEDICATION WITH ELECTROMODULATION MAY BE PRACTICAL.**
INTERNATIONAL NEUROMODULATION SOCIETY
12TH WORLD CONGRESS

Number of Presentations

- Pain: 50
- Spinal Cord Stimulation: 40
- Deep Brain Stimulation: 30
- Spasticity: 20
- Cardiac Function: 10
- Epilepsy: 10
- Pelvic Organs: 10
- PNS + Viscera + Inflammation: 10
- Gastrointestinal: 5

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DISORDERS TO TREAT WITH NEUROMODULATION

ACHALASIA
DYSPHAGIA
GERD
MEGA ESOPHAGUS

COLITIS
IBS
CROHN’S DISEASE
HIRSCHSPRUNG DISEASE
CHAGAS DISEASE

GASTROPARESIS
GUT DYSMOTILITY
DYSPEPSIA
VISCERAL PAIN
NAUSEA, EMESIS
OBESITY
PYLORIC STENOSIS
DUMPING
REFLUX

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TIME
The Obesity Epidemic in America

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ROUX-EN-Y BYPASS

- Bypassed portion of stomach
- Gastric pouch
- Bypassed duodenum
- Jejunum
- Food
- Digestive juice

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Great and Desperate Cures
The Rise and Decline of Psychosurgery and Other Radical Treatments for Mental Illness

- DESPERATE PATIENTS
- ABSENCE OF SATISFACTORY PHARMACOLOGICAL TREATMENTS
- POPULAR MEDIA HYPE
- ABSENCE OF A SOLID MECHANISTIC UNDERSTANDING
- UNCRITICAL ACCEPTANCE OF PROONENT’S CLAIMS
- MYOPIA REGARDING SIDE EFFECTS

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NEUROMODULATION: THE AUTONOMIC NERVOUS SYSTEM AND GASTROINTESTINAL TRACT DISORDERS
ENTERIC NERVOUS SYSTEM:

"LITTLE BRAIN" IN GUT
COMPLEXITY MADE SIMPLE
The VAGUS may be the answer!!

COMPLEXITY MADE SIMPLE
Leblanc, 2001
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ROUX-EN-Y BYPASS

VAGAL NETWORK

INCISION

Gastric pouch

Bypassed portion of stomach

Bypassed duodenum

Jejunum

food

digestive juice
VAGAL MOTOR INNERVATION OF MYENTERIC PLEXUS
VAGAL & SYMPATHETIC MOTOR - MYENTERIC PLEXUS
VAGAL SENSORY INNERVATION: INTRAGANGLIONIC LAMINAR ENDING (IGLE)
VAGAL SENSORY - IGLes - PLATES ON MYENTERIC GANGLIA
VAGAL SENSORY IGLE INNERVATES CHOLINERGIC NEURONS & IGNORES NITRERGIC NEURONS IN MYENTERIC GANGLION
VAGAL SENSORY INNERVATION: INTRAMUSCULAR ARRAY (IMA)
VAGAL SENSORY IMAs:
STRETCH RECEPTORS?
MUSCLE SPINDLE ORGAN ANALOGUES?
AXON REFLEXES?
IMAs ARE REGIONALLY SPECIALIZED AND CONCENTRATED:

SPHINCTERS, FORESTOMACH, ETC.
OBESITY: VBLOC THERAPY

NEUROREGULATOR

CONTROLLER

ELECTRODES

TRANSMIT COIL

Sarr et al., 2012

Fig 1. Electrodes implanted on anterior and posterior vagal trunks (original magnification, ×4).

Camilleri et al., 2008
VAGAL MOTOR INNERVATION: ESOPHAGUS

Powley et al., 2013
ENTERIC NERVOUS SYSTEM: "LITTLE BRAIN" IN GI TRACT

Furness & Costa
VAGAL SENSORY AXONS INNERVATE GI MUCOSAL VILLI WITH CHEMORECEPTORS

Powley et al., 2011
VAGAL SENSORY AXONS ALSO INNERVATE CRYPTS
• MULTIPLE REFRACTORY GI DISORDERS EXIST.

• VISCERAL ATLASES OF THE GI TRACT ARE AVAILABLE.

• REMEDIATION WITH ELECTROMODULATION MAY BE PRACTICAL.
GI NEUROMODULATION PRIORITIES

• HIGH-PRIORITY OPPORTUNITIES:
  - OBESITY
  - GASTROPARESIS

• TECHNOLOGICAL NEEDS:
  - NEXT-GENERATION STIMULATORS
    - Fiber-caliber tuned
    - Closed Loop
    - Self-programming, real time
  - DATA ON VAGAL INTEGRATIVE ARCHITECTURE
MACROPHAGES INTERACT WITH:
MYENTERIC GANGLIA (AND EXTRINSIC NERVE AXONS)

Phillips & Powley, 2012
MACROPHAGES INTERACT WITH:

MYENTERIC GANGLIA (AND EXTRINSIC NERVE AXONS)

Phillips & Powley, 2012
SYMPATHETIC GANGLION (CELIAC) EXPOSED FOR SURGERY
SYMPATHETIC MOTOR AXONS CO-INNervate SMOOTH MUSCLE AND MYENTERIC GANGLIA
GASTRIC BYPASS

- DESPERATE PATIENTS
- ABSENCE OF SATISFACTORY PHARMACOLOGICAL TREATMENTS
- POPULAR MEDIA HYPE
- ABSENCE OF A SOLID MECHANISTIC UNDERSTANDING
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ENTERIC NERVIOUS SYSTEM: "LITTLE BRAIN" IN GI TRACT

Furness, 2006

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VAGAL MOTOR - MYENTERIC PLEXUS
GASTROPARESIS: GASTRIC STIMULATION

Fig. 2 Depiction of laparoscopic gastric electrical stimulation placement with trocar placement and intraoperative endoscopy.
VAGAL MOTOR INNERVATION OF ESOPHAGUS:
CO-INNERVATION OF MUSCLE FIBERS AND GANGLIA

Powley et al., 2013