SPINOVISCERAL REFLEXES: From Paraspinal Tissues to Autonomic Effects

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VISCEROVISCERAL INTERACTIONS

SOMATOVISCERAL INTERACTIONS

SPINOVISCERAL INTERACTIONS
WHAT’S IN A NEUROPHYSIOLOGICAL TERM?

“Cause and Effect Relationships”

SOMATOVISCERAL INTERACTIONS

Musculoskeletal System

Somatosensory Afferents

Somatomotor & Somatosensory Pathways

Central Integration

Sympathetic & Parasympathetic Efferent Pathways

Visceral Afferents

Visceral Organs

VISCEROSOMATIC INTERACTIONS
WHY FOCUS ON SOMATOVISCERAL INTERACTIONS?

OMT most often directed at the musculoskeletal system
WHY FOCUS ON SPINOVISCERAL INTERACTIONS?

• Vertebral column constitutes an important focus in osteopathic diagnosis and manipulative treatment.

• It comprises a lot of musculoskeletal real estate.

• It contains a dense network of joints and ligaments.
  – 50 zygapophyseal joints
  – 13 intervertebral body joints (IVD)

• It is a complex, multi-layered muscle system.

• All structures are neurally-innervated except potentially the inner 2/3 of the IVD.
GOALS OF PRESENTATION

• Present the current state of our knowledge regarding spinovisceral interactions based upon:
  – basic science studies in animal preparations
  – peer-reviewed literature
  – controlled or experimental variable: the mechanical or chemical condition of paraspinal tissues
  – response variable: sympathetic nerve discharge (SND) to visceral organ


1st study to look specifically at the potential for a reflex interaction between stimulation of paraspinal tissues and sympathetic innervation to an viscera.

Effect of mechanosensory stimulation on renal and adrenal sympathetic nerve activity (SND).
SUMMARY OF METHODS

- Chloralose/urethane anesthetized rats.
- Isolated thoracic and lumbar segments.
- Vertebra exposed by removing muscle attachments to the vertebra.
- Thoracic and lumbar vertebra were mechanically moved.
- Renal and adrenal SND measured.
- Threshold crossings were counted as impulses and placed into 5 second bins.
MECHANICAL INPUT

Clamp

Lateral Flexion
Force (0.5-3 kg)

Clamp
Movement increased blood pressure → barodenervation.
Vertebral movement inhibited SND (open symbols).
Inhibitory responses maximal with mechanical forces of 2.0 kg (> 400% BW).

Redrawn from Sato & Swenson
JMPT 7(3): 141-147, 1984
Inhibitory response was a reflex because cutting dorsal roots abolished it.

Spinalization between C₁-C₂ reversed the inhibition to an excitation.

- 30-40% increase in adrenal and renal SND.
CONCLUSION

- **Mechanosensory** input due to lateral bending of the thoracic and lumbar vertebral column reflexly inhibited sympathetic outflow to the kidney and adrenal glands.

- Reflex likely arose from non-muscular tissue.

- Inhibitory response to kidney was larger and longer lasting than to adrenal gland.

- Inhibition from activation of supraspinal centers which overcame an excitatory segmental response.

- 1st study to look at the potential for reflex effects between chemosensory stimulation of paraspinal tissues and the sympathetic nervous system.

- Effect of capsaicin on adrenal nerve activity.
SUMMARY OF METHODS

• Chloralose/urethane anesthetized rats.
• Spine intact.
• Capsaicin or saline injection into thoracic and lumbar interspinous spaces.
• 10mM, 20ul, midline cephalad margin of caudal spinous.
• Adrenal SND recorded & adrenal catecholamine secretion (from adrenal vein).
• Threshold crossings were counted as impulses and placed into 5 second bins.
ADRENAL SYMPATHETIC NERVE DISCHARGE to CHEMICAL STIMULATION OF THORACIC TISSUES

CATECHOLEAMINE SECRETION IN RESPONSE TO CHEMICAL STIMULATION OF THORACIC TISSUES

Non-Spinalized (n=4)

C1-C2 Spinalized (n=4)

CATECHOLEAMINE SECRETION IN RESPONSE TO CHEMICAL STIMULATION OF LUMBAR TISSUES

Non-Spinalized
(n=5)

C1-C2 Spinalized
(n=4)

Saline
Cap

% of Control

Time (min)

Epinephrine
Norepinephrine

Redrawn from Budgell et al.
CONCLUSION

• Unlike paraspinal mechanosensory input’s inhibition of adrenal SND, noxious chemosensory input had an excitatory influence on the adrenal gland.

• The excitatory influence was mediated segmentally and did not require supraspinal input although the latter may amplify the effect.
UNPUBLISHED DATA

Effect of controlled, prolonged mechanical loading of a lumbar vertebra on renal, splenic, lumbar & adrenal SND in the rat

• Palmer Center for Chiropractic Research
  – Joel Pickar
  – Charles Henderson
  – Ram Gudavalli

• Kansas State University
  – Michael Kenney
  – Richard Fels, technical assistance

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MECHANICAL LOADING
(anterior flexion)

A) [Image of mechanical loading apparatus]

B) [Image showing pulled under displacement control]

C) [Image showing fixed connection]
FORCE-DISPLACEMENT CURVES to FAILURE to establish graded loading

Force (grams) vs. Displacement (mm)

Mean

n=13
CONCLUSION

Mechanosensory stimulation with anterior vertebral flexion:

• Renal SND
  – relatively little effect regardless of stimulus strength

• Lumbar SND
  – possibly inhibitory with mildly noxious stimulation

• Adrenal & Splenic SND:
  – excitatory with noxious stimulation
Determine if **mechanosensory** input from lumbar vertebral movement reflexly alters SND to kidney or spleen.

Determine if **chemosensory** (inflammatory) input from lumbar paraspinal muscles reflexly alters SND to kidney or spleen.

Determine the **interaction** between mechano- and chemosensory input on kidney and spleen SND.
SUMMARY OF METHODS

• 20 anesthetized adult cats.
• L₃ loaded dorsal-ventral at spinous process, 100%BW.
• Injections into the multifidus muscle.
• RENAL: Cardiovascular regulation and fluid balance.
• SPLEEN: Immune function as a secondary lymphoid tissue.
• Post-ganglionic sympathetic activity confirmed at the end of the experiment using ganglionic blocker hexamethonium (30mg/kg, iv) and subtracted from signal.
• SND rectified, integrated (τ = 10ms) into 25 sec bins.
MECHANORESORY INPUT
(anterior displacement of the L₃ vertebra)
**CHEMOSENSORY INPUT**

**Mustard oil**
- 20%, 2 inj/muscle, 10 µl/injection,
- 60 µl total

**Vehicle**
- mineral oil,
- 2 injections /muscle,
- 10 µl/injection,
- 60 µl total

**REFLEX DETERMINATION**

Medial branch from T_{11} - L_{5} was located near the root of the left superior articular pillar of T_{12} - L_{6} and cut
INFLAMMATORY STIMULUS ALONE

MECHANICAL + INFLAMMATORY STIMULUS

N=7

VERTEBRAL POSITION ALONE

VERTEBRAL POSITION + MUSTARD OIL INJECTION

REFLEX DETERMINATION

N=4

VERTEBRAL POSITION + MUSTARD OIL INJECTION

Graphs showing changes in load, displacement, BP, HR, Renal SND, and Splenic SND with and without mustard oil injection.
EXPERIMENT 5

SUPRASPINAL INFLUENCE

Spinal Cord Transection
(with vertebral load)

N=6

INJECT load
CONCLUSION

- Mechanosensory input from lumbar paraspinal tissues did not affect sympathetic outflow to the spleen or kidney.
- However, inflammatory, chemosensory input from the multifidus muscle elicited a spinovisceral reflex that increased sympathetic outflow to the spleen and kidney and increased heart rate.
- Combined mechano and chemosensory input may prolong the increases.
- Reflex required supraspinal integration.
Influence of innocuous cervical vertebral movement on the efferent innervation of the adrenal gland in the rat.

• To determine if mechanosensory input from the cervical vertebra alters SND to adrenal gland.
SUMMARY OF METHODS

- Chloralose- anesthetized rats.
- C₂ (axis) vertebra rotated 2°, 6°, 12°, 20°, 25°, 30°.
- Slow trapezoid ramp (12°/sc) and hold (2s) rotations.
- Head fixed to abolish vestibular activity.
- Adrenal gland SND measured.
Increasing # of vertebra moving

visually, no coupled motion

begin to get $C_3$ coupled motion

begin to get $T_1$ coupled motion

SUMMARY

• WHAT WE KNOW

  – Noxious/inflammatory chemical stimulation of paraspinal tissues increases sympathetic outflow to a number of viscera (kidney, spleen and adrenal gland).

  – Innocuous mechanical stimuli isolated to a vertebral segment seem to be without effect on SND.

  – Supraspinal systems can affect whether a sensory stimulus is ultimately excitatory or inhibitory.

• WHAT WE DON’T KNOW

  – Conflicting evidence on whether increasingly noxious mechanical stimulation is excitatory or inhibitory to the sympathetic nervous system.
TECHNICAL CHALLENGES FOR EXPERIMENTAL DESIGNS STUDYING SPINOVISCERAL INTERACTIONS

• Identification of the stimulus modality
  – mechanical vs. chemical stimuli may have opposing effects

• Characterization of the magnitude of mechanical stimulation
  – noxious vs. innocuous

• Identification of spinal tissues being stimulated
  – (muscle vs. non-muscle may have opposing effects)

• Spinal level of stimulation
  – Sensory input from different segmental levels may produce different effects
Thank You
&
Questions