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Effects of T1-T12 dorsal arthrodesis on
thoracic cage and chest organs.
Anatomical, histological and radiological study
on pre-pubertal New Zealand White rabbits

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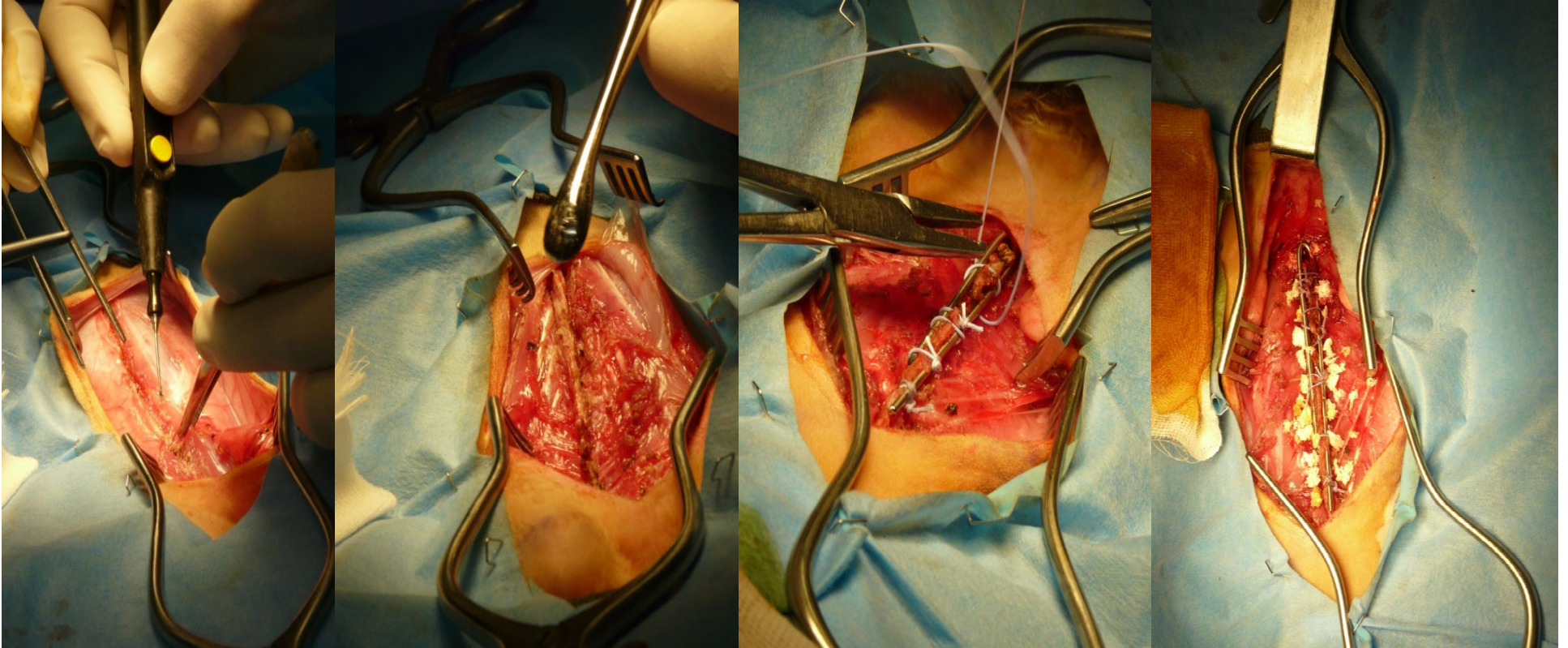
**Effects of T1-T12 dorsal arthrodesis on
thoracic cage and chest organs.
Anatomical, histological and radiological study
on pre-pubertal New Zealand White rabbits**

Conflict of interest disclosure: N/A

Aim of the Study

To evaluate clinical, anatomical, histological and radiological changes induced in New Zealand White rabbits subjected to T1-T12 arthrodesis

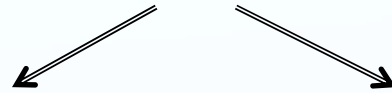
Surgical Procedure



Extra-canal T1-T12 dorsal arthrodesis

Methods

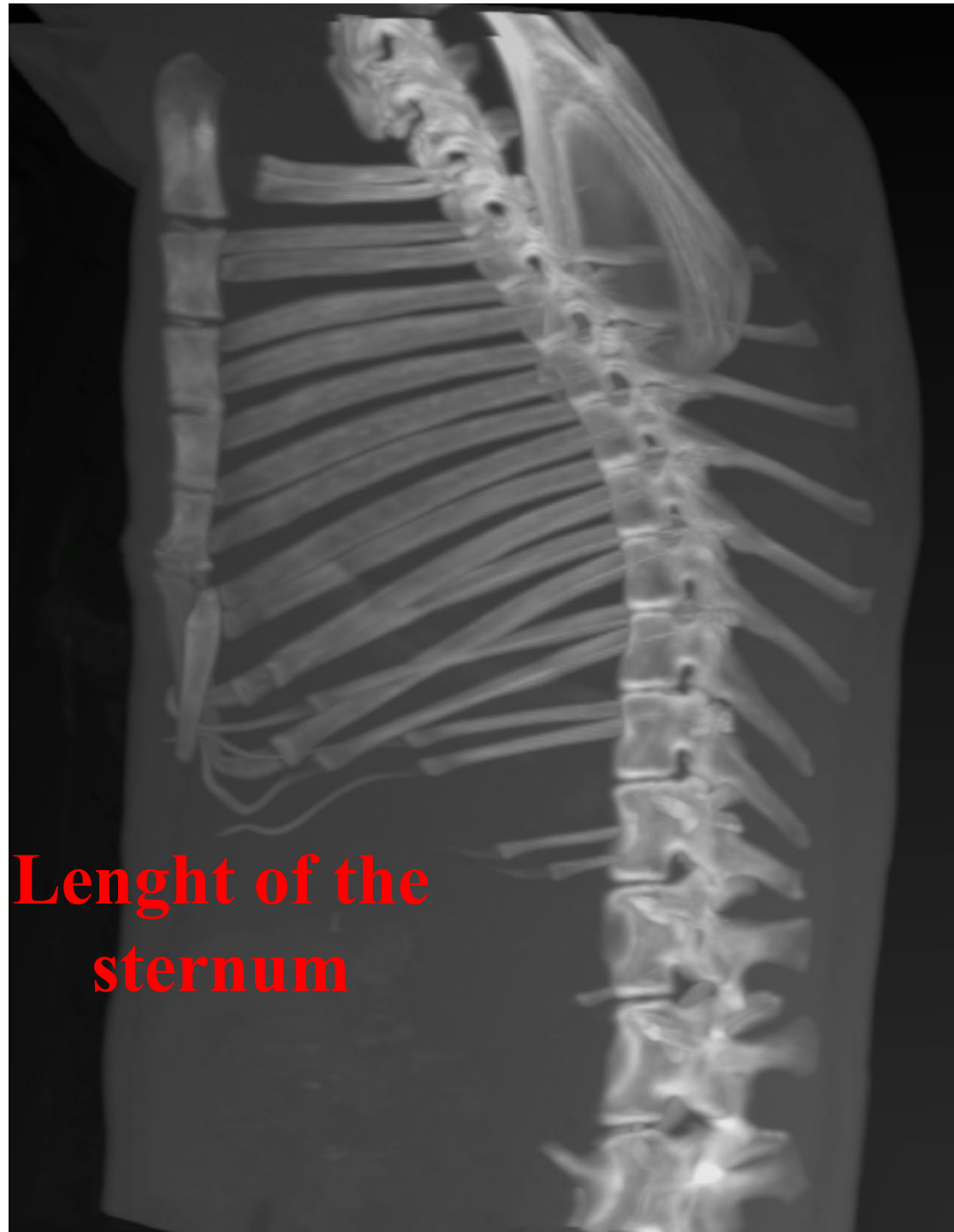
54 female pre-pubertal NZW rabbits, 6 weeks old



32 operated

22 sham

Follow-up: 16 months



Methods

**Random suppressions:
1½, 4, 8, 12 and 16 months after surgery**

- Chest Computed Tomography
- **Clinical evaluation**
- Blood gas analysis
- Cortisol determinations
- Echo-cardio color doppler

Methods

**Random suppressions:
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- Clinical evaluation
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- Cortisol determinations
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PCO₂
PO₂
TCO₂
HCO³
sO₂
pH

Methods

**Random suppressions:
1½, 4, 8, 12 and 16 months after surgery**

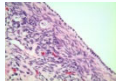
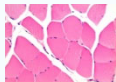
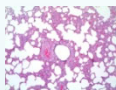
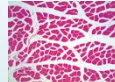
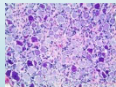
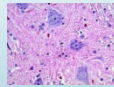
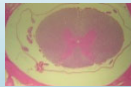
- Chest Computed Tomography
- Clinical evaluation
- Blood gas analysis
- **Cortisol determinations** \xrightarrow{RIA} **Hair Plasma**
- Echo-cardio color doppler

Methods

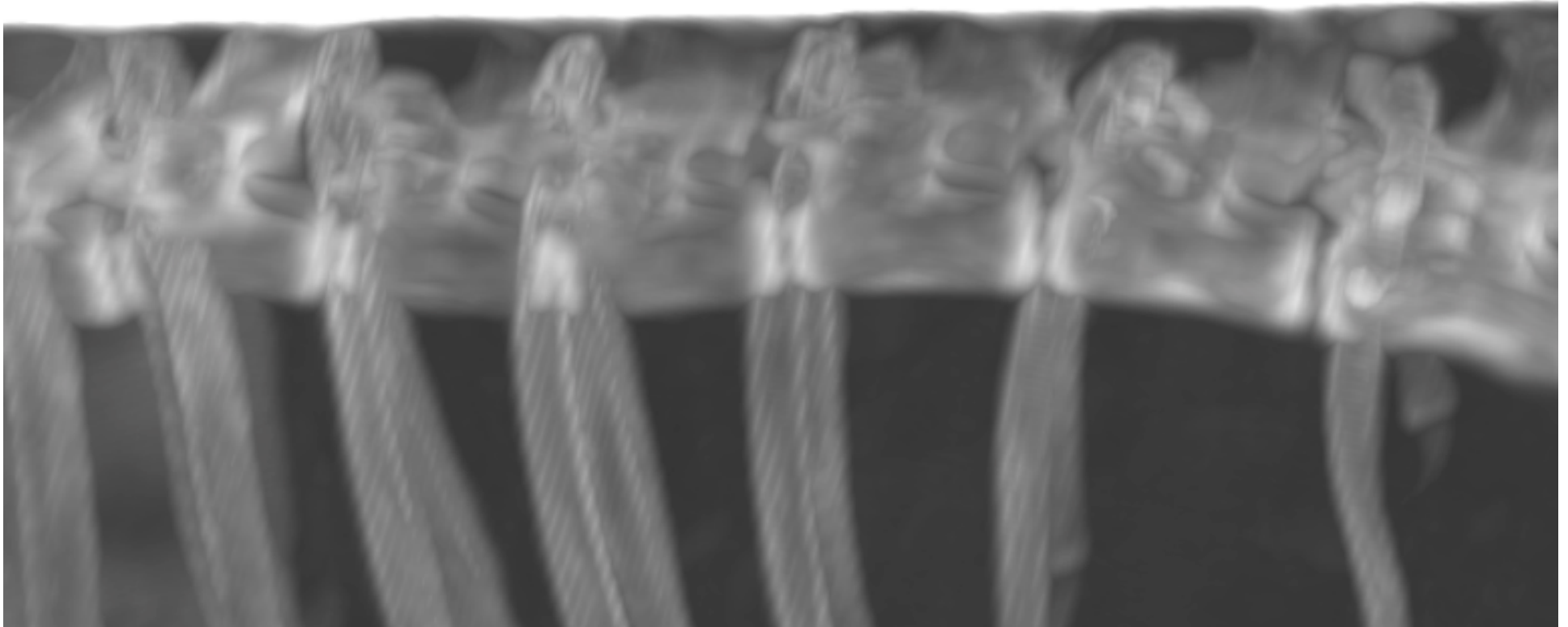
**Random suppressions:
1½, 4, 8, 12 and 16 months after surgery**

- Chest Computed Tomography
- Clinical evaluation
- Blood gas analysis
- Cortisol determinations
- **Echo-cardio color doppler**

Methods

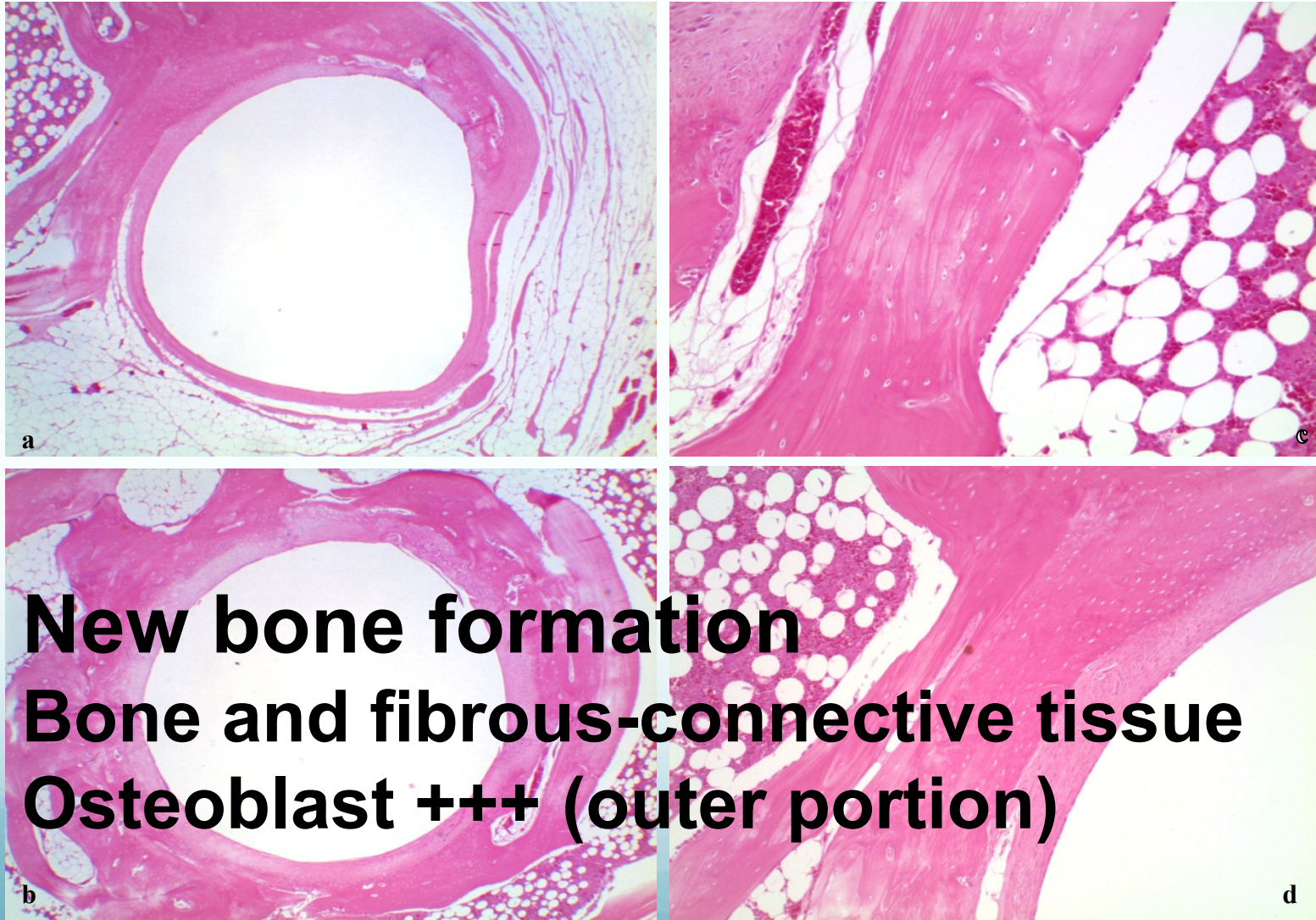
- **Macroscopic evaluation of heart and lungs**
 - Weight
 - Volume
- **Microscopic evaluation**
 - Ovaries 
 - Heart 
 - Lungs 
 - Intercostals muscles and diaphragm 
 - Spine, spinal cord and ganglia   

Results: CT scan Fusion



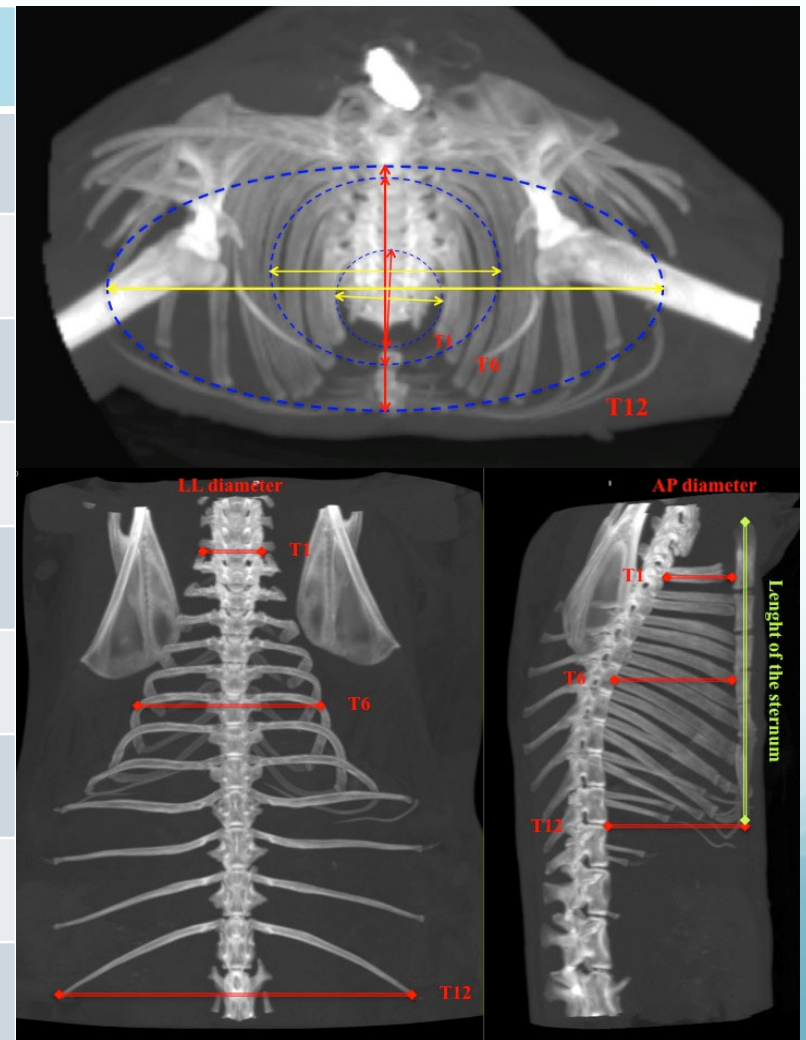
Results: Histological Fusion

OPERATED. BONE FUSION. 1 Y. POST SURGERY (a-d)



Results: Thoracic Dimensions

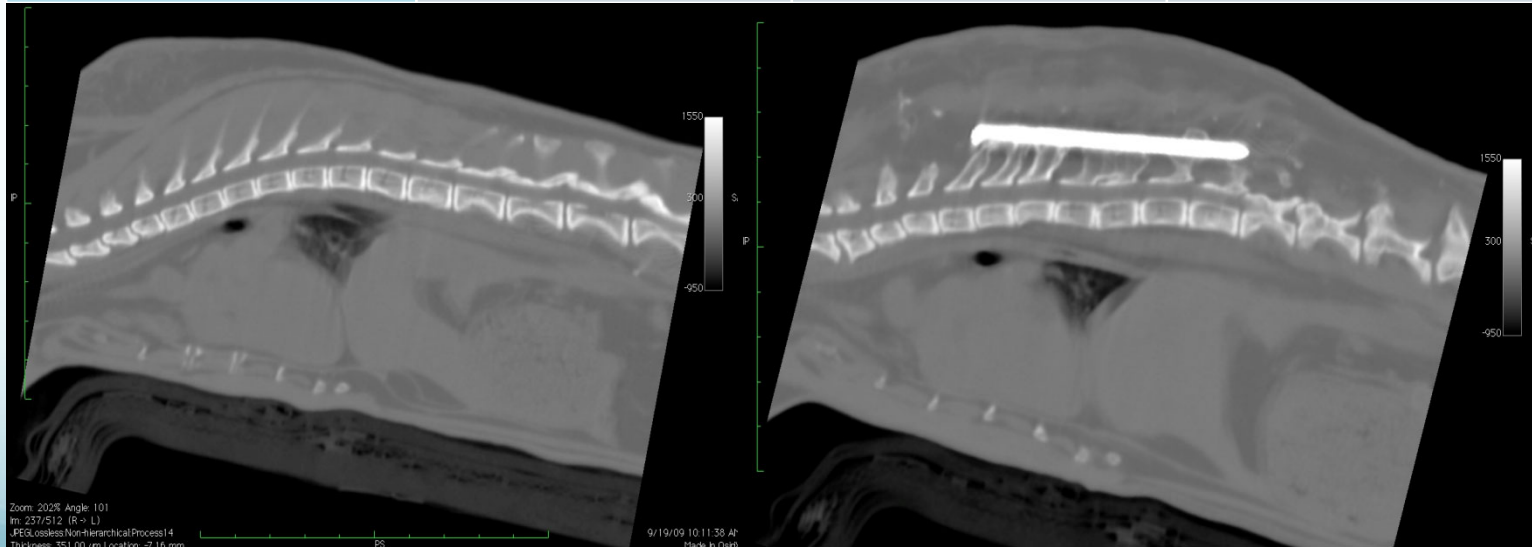
| | Thoracic Level | SHAM | OPERATED | |
|---------------------|----------------|-------|----------|----------------|
| Thoracic Depth (cm) | T1 | 2.30 | 2.20 | ↘ |
| | T6 | 4.38 | 4.06 | ↘ |
| | T12 | 5.20 | 5.11 | = |
| Thoracic Width (cm) | T1 | 2.33 | 2.41 | = |
| | T6 | 6.15 | 6.57 | ↗ ⁰ |
| | T12 | 10.50 | 12.07 | ↗ ⁰ |
| Depth/Width ratio | T1 | 0.99 | 0.91 | ↘ |
| | T6 | 0.71 | 0.62 | ↘ ⁰ |
| | T12 | 0.50 | 0.42 | ↘ ⁰ |



⁰T-Student and Wilcoxon Tests

Results: Thoracic Dimensions

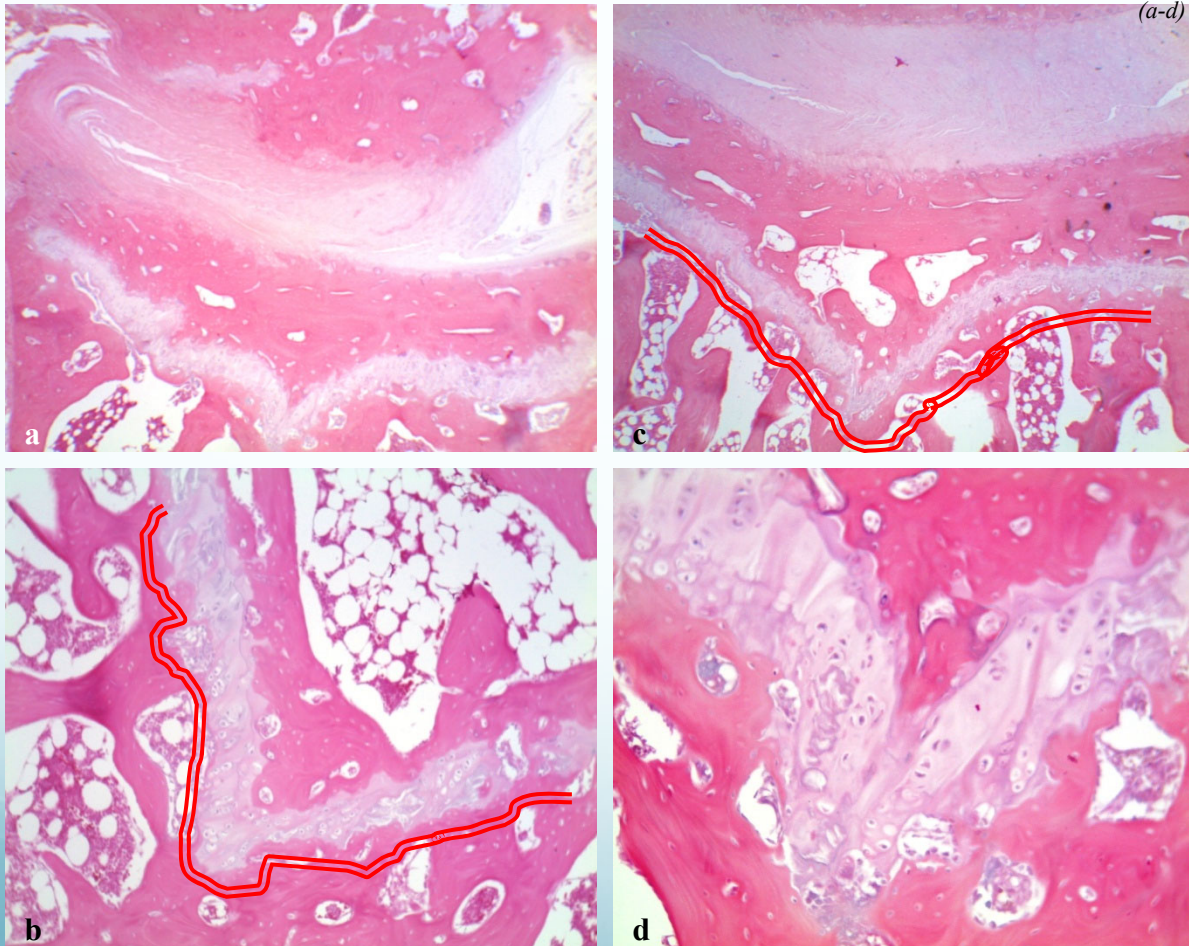
| | SHAM | OPERATED | |
|----------------------------|------------|------------|----|
| Length of the Sternum (cm) | 10.98±0.09 | 10.47±0.10 | ↘ |
| T1-T12 length (cm) | 14.33±0.16 | 14.06±0.22 | ↘ |
| KYPHOSIS | 36.5°±4.0° | 8.0°±3.71° | ↘° |



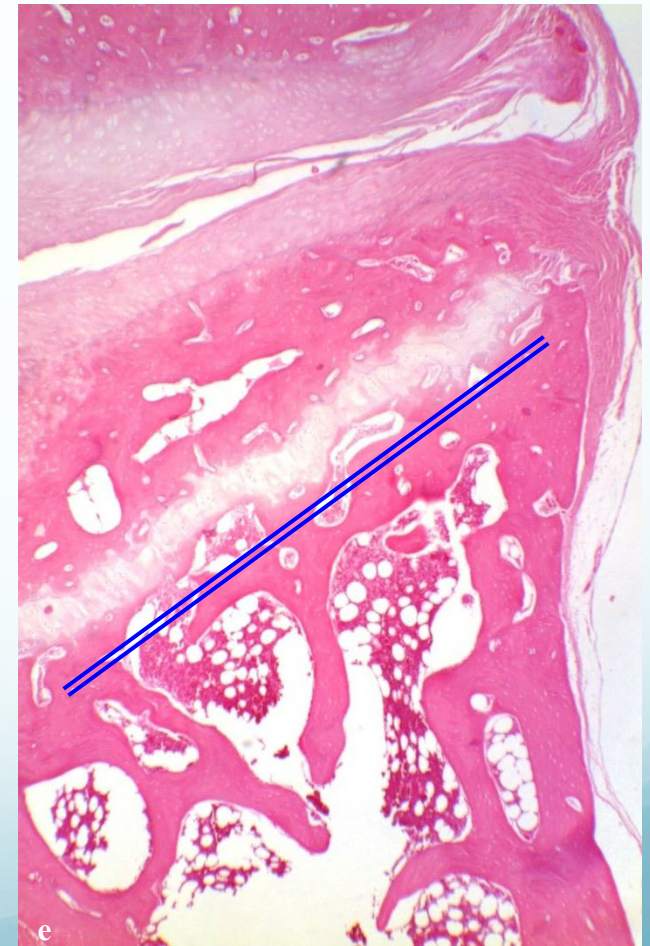
°T-Student and Wilcoxon Tests

Cartilage disorganization

OPERATED. VERTEBRAL BODY. GROWTH CARTILAGE. 3 M. POST SURGERY

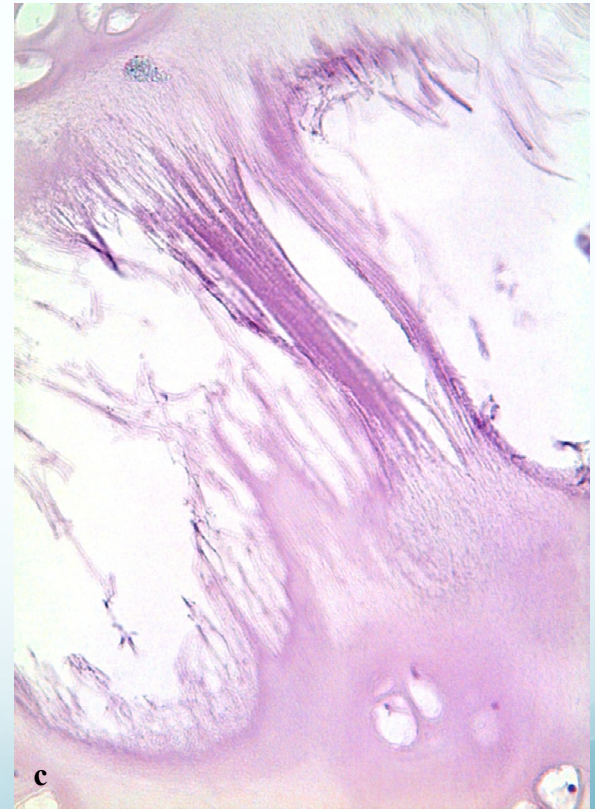
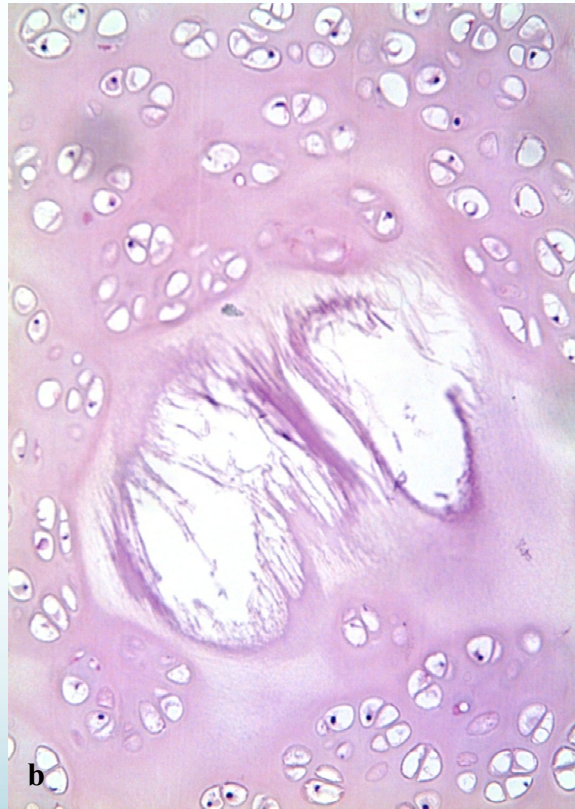
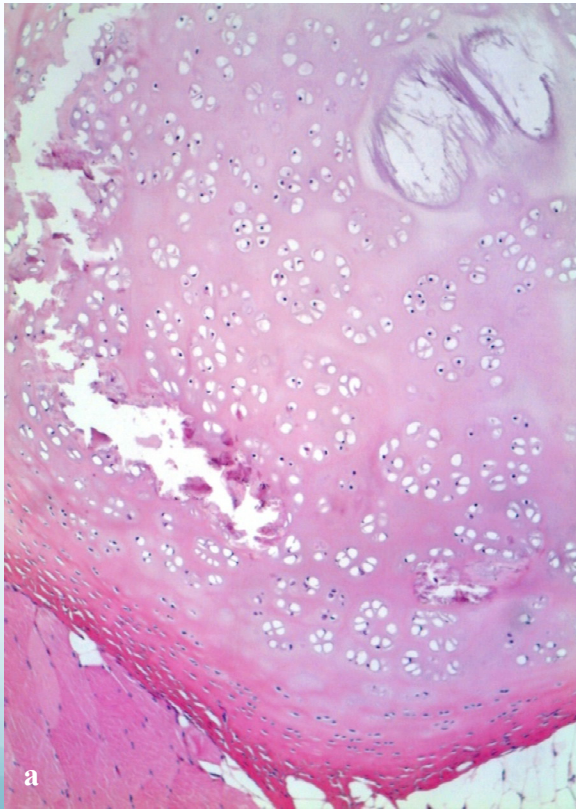


SHAM. 3 M. POST SURGERY (e)

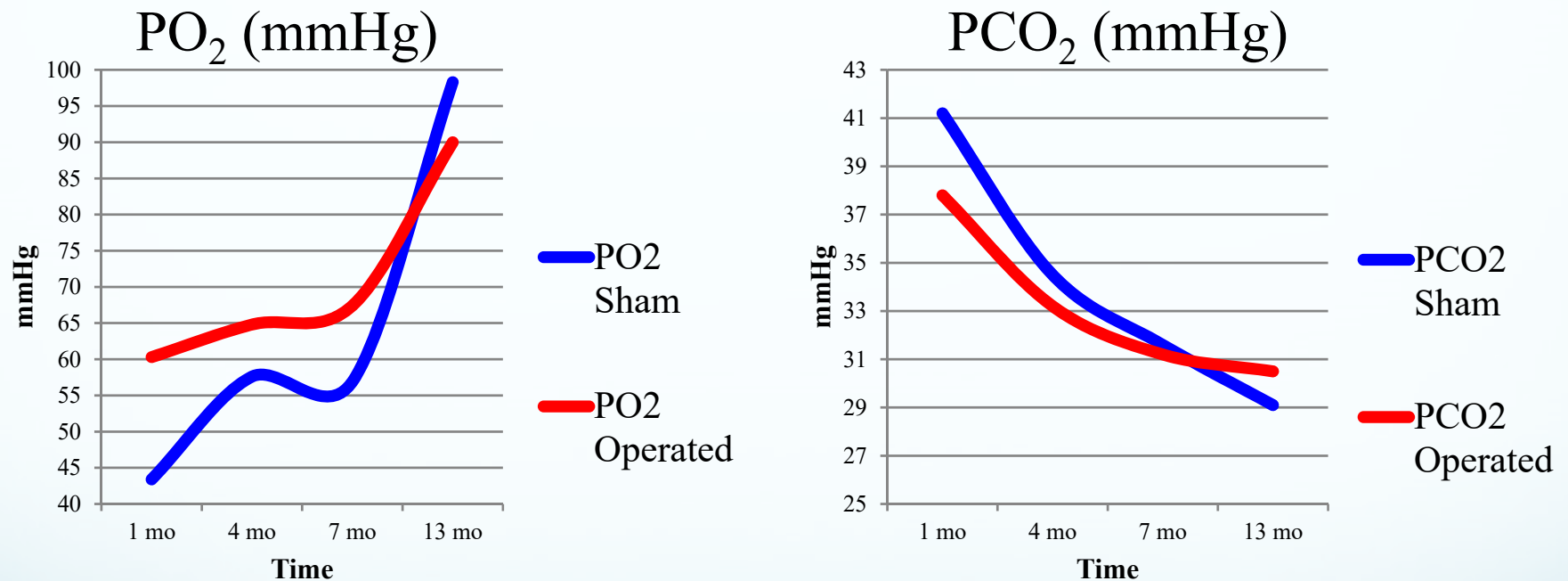


Cartilage disorganization

OPERATED. RIB CARTILAGE. 12 M. POST SURGERY (a-c)

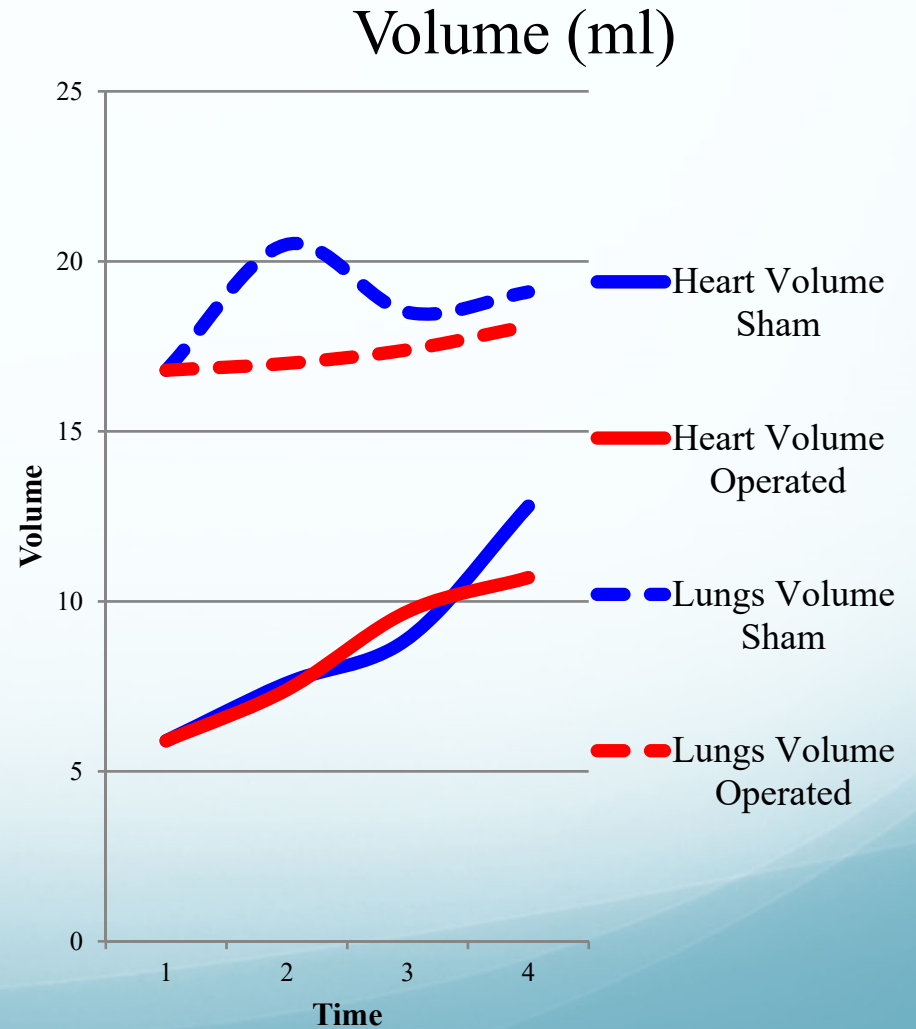
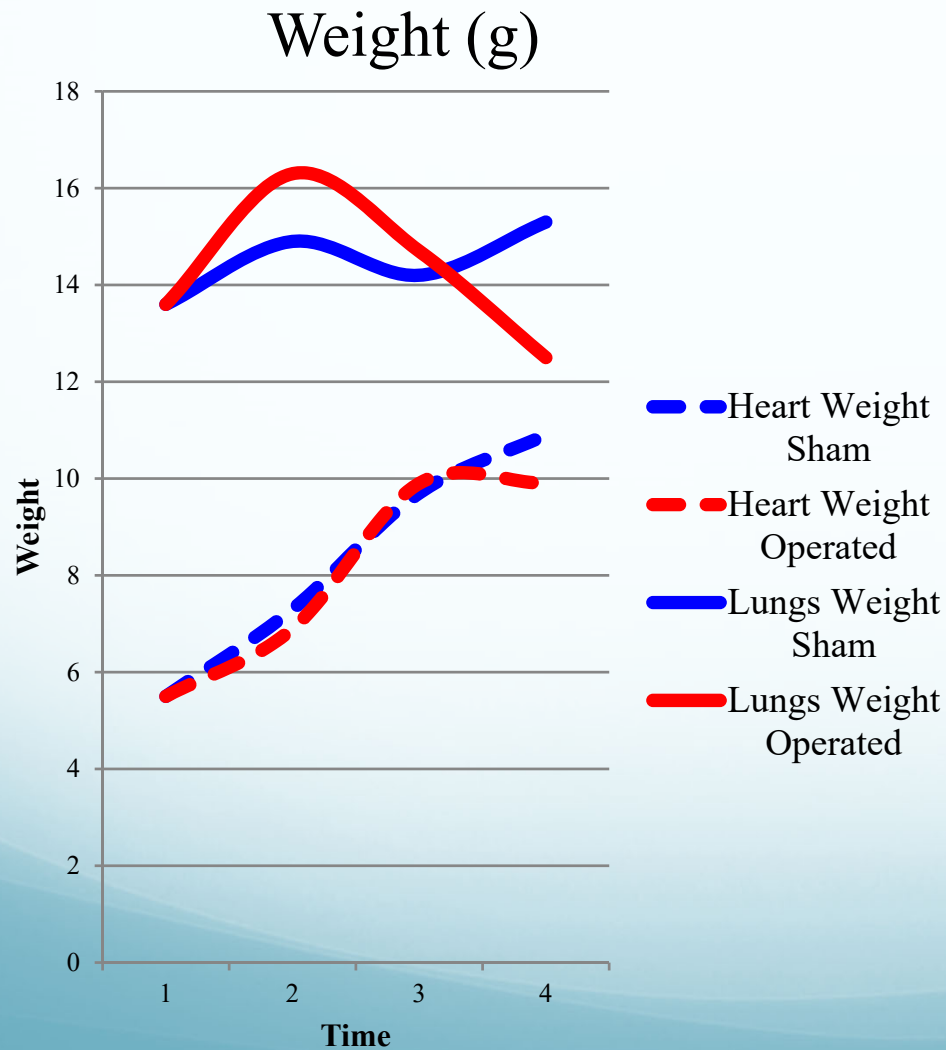


Results: Blood Gas Analysis



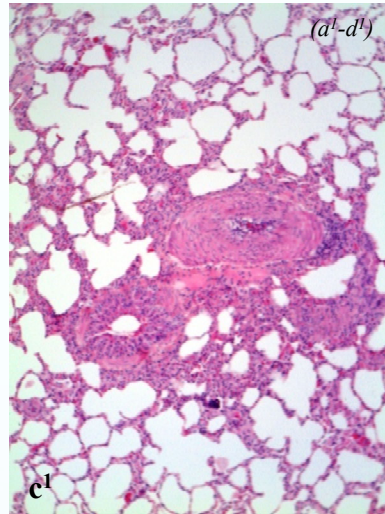
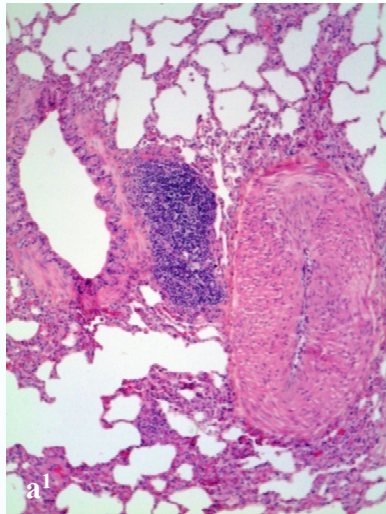
TCO₂, HCO₃⁻, sO₂ and pH showed no significant difference

Results: Heart and Lungs

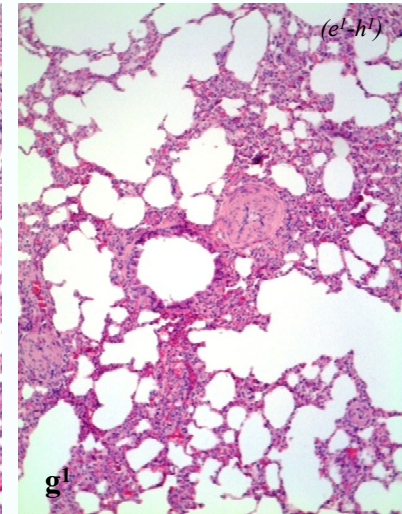
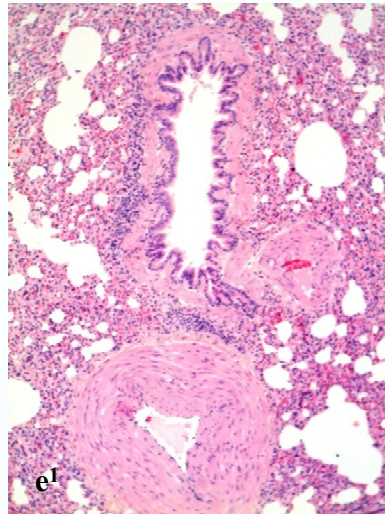


Microscopic evaluation: Lungs

OPERATED. LUNGS. 12 M. POST SURGERY



OPERATED. LUNGS. 12 M. POST SURGERY

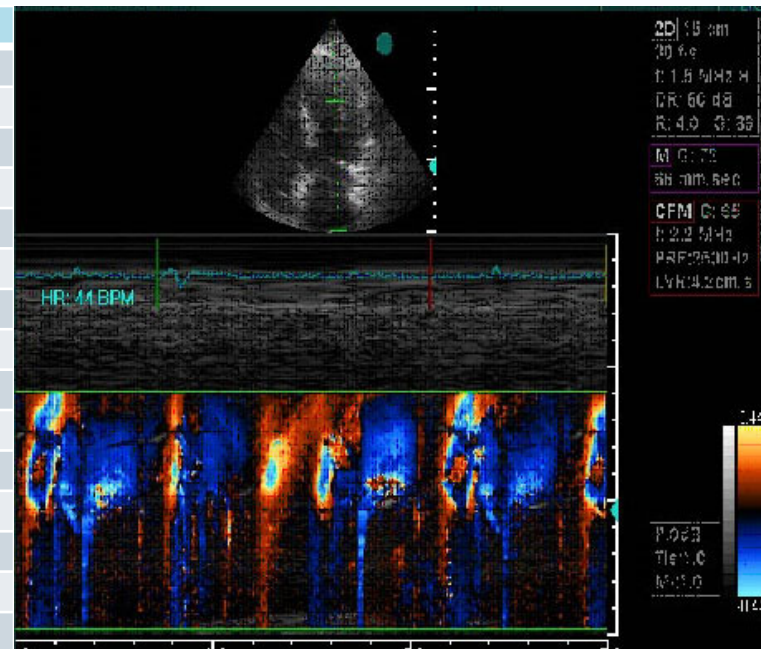


Thickening Alveolar Wall
Areas of Atelectasia
Areas of Enphisematous changes
Linfocitary Infiltration
Absence of edema

Results: Echo-cardio color Doppler

**At skeletal maturity,
cardiac function is preserved**

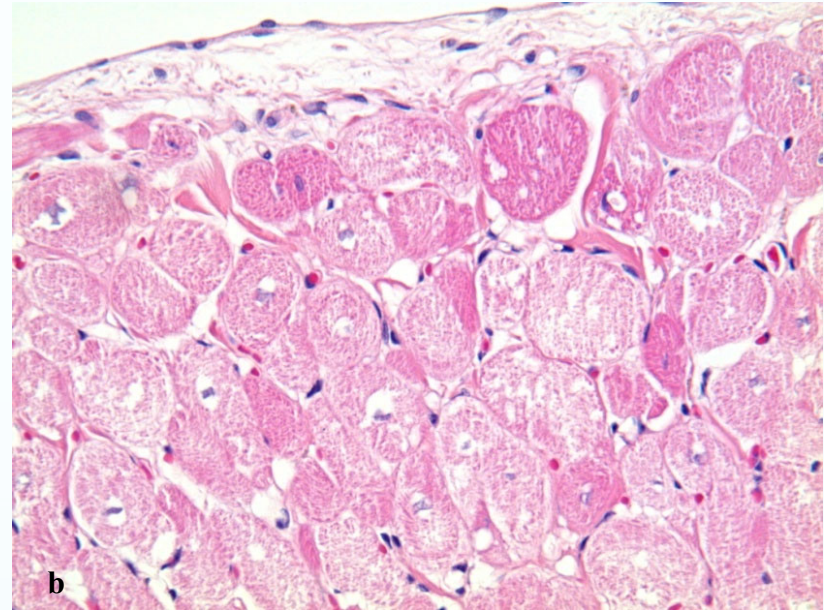
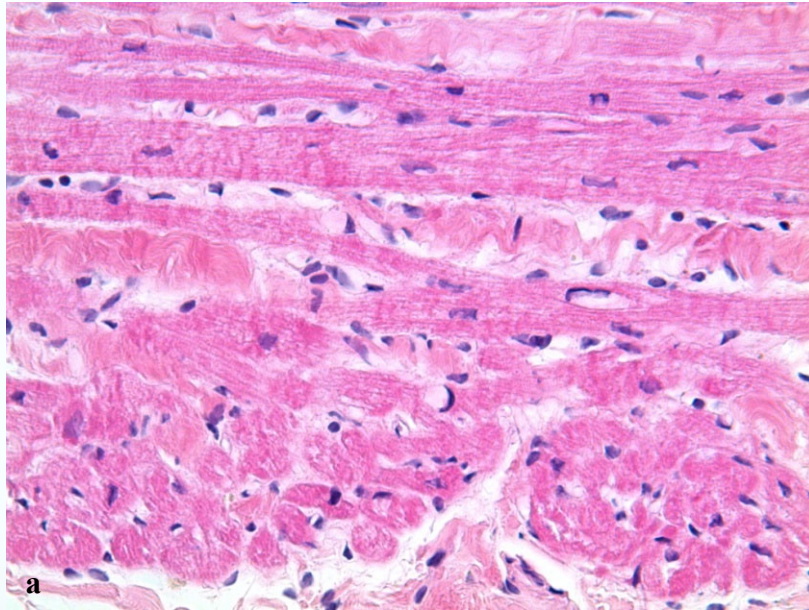
| | SHAM | OPERATED |
|------------------|------------|------------|
| SivD (mm) | 3.39±0.33 | 3.06±0.47 |
| DVSD (mm) | 15.74±1.55 | 15.68±1.22 |
| PPVSD (mm) | 3.53±0.28 | 3.49±0.41 |
| SivS (mm) | 4.26±0.32 | 3.9±0.33 |
| DVSS (mm) | 11.44±1.13 | 11.49±2.15 |
| PPVSD (mm) | 4.23±0.39 | 4.02±0.65 |
| FA (%) | 29.71±3.17 | 36.00±4.67 |
| FE (%) | 60.71±6.33 | 68.78±6.20 |
| AS (mm) | 10.66±0.95 | 10.82±0.66 |
| Ao (mm) | 7.63±0.43 | 8.16±0.80 |
| AS/Ao | 1.31±0.13 | 1.29±0.11 |
| Ao Vel Max (m/s) | 0.79±0.12 | 0.72±0.14 |
| Ao Gpmax (mmHg) | 2.73±0.85 | 2.22±0.76 |
| Po Vel Max (m/s) | 0.68±0.10 | 0.66±0.11 |
| Po Gpmax (mmHg) | 1.93±0.62 | 1.84±0.58 |



*T-Student and Wilcoxon Tests

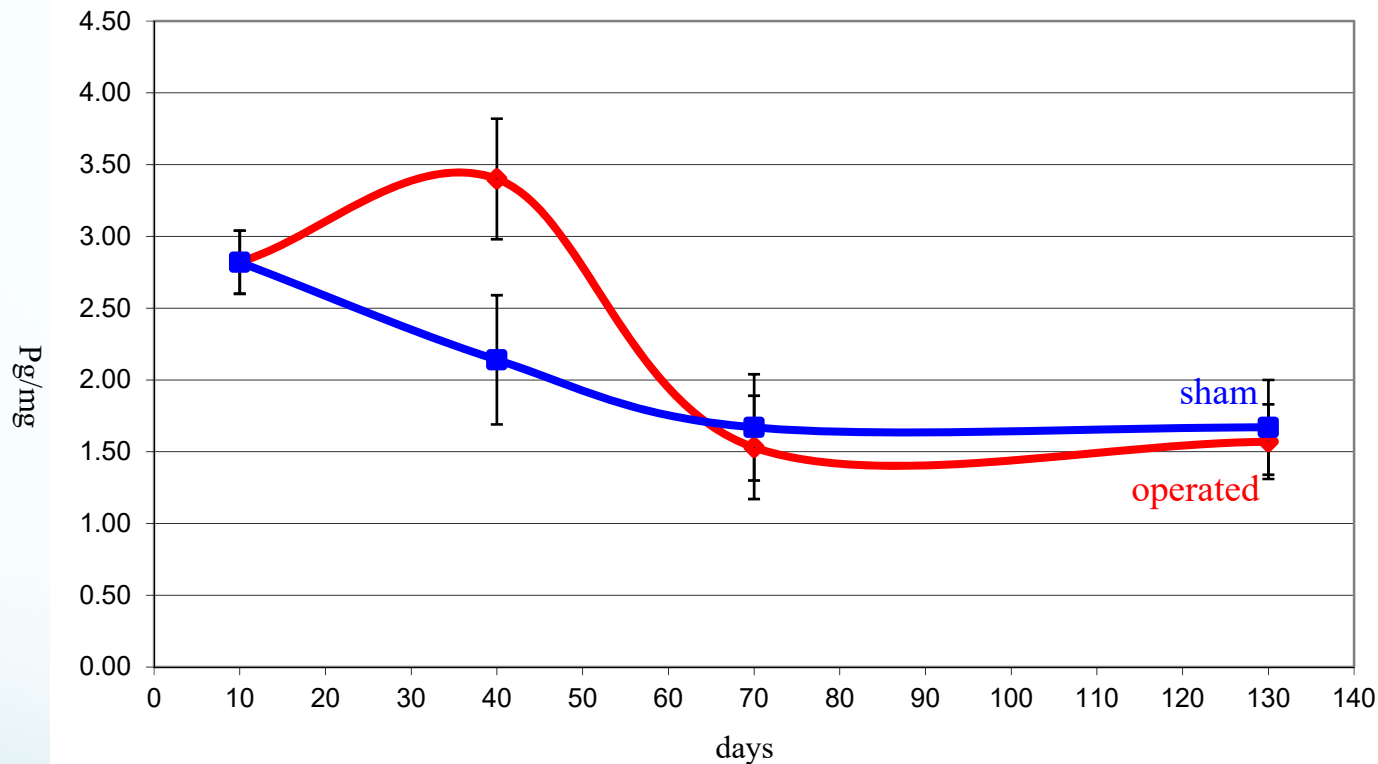
Microscopic evaluation: Heart

OPERATED. VENTRICULAR and MYCARDIAL MUSCLE. 12 M. POST SURG (a-b)



Normal Histological appearance of:
Left Ventricle
Right Ventricle
Inteventricular septum

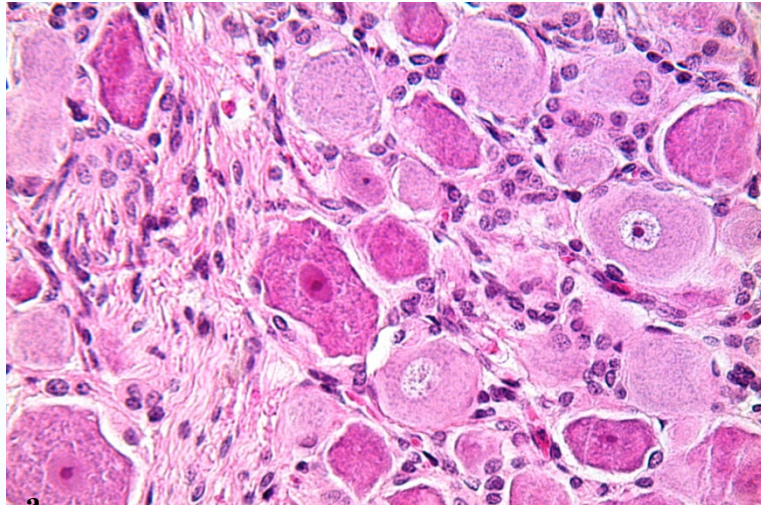
Results: Cortisol determinations



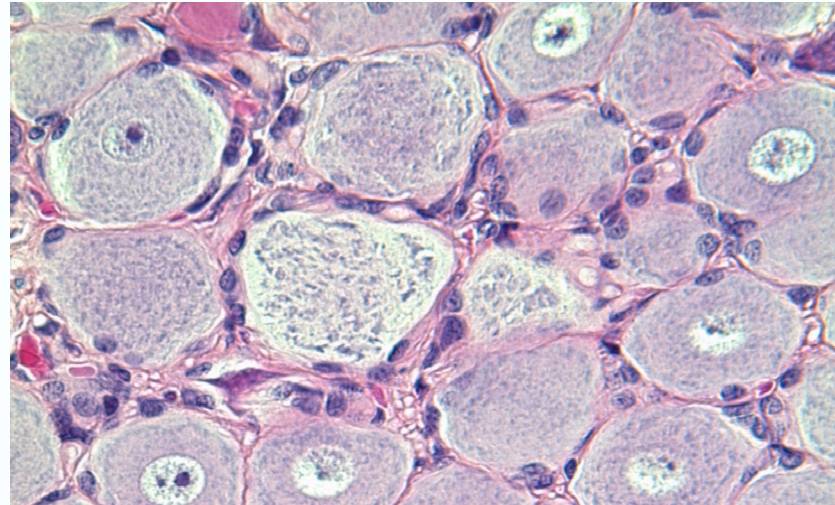
Cortisol levels were determined after 24/hours methanol extraction followed by evaporation of the solvent and reconstitution of the extract in assay buffer, and analysis of the extracted cortisol by radioimmunoassay. Validation parameters of the analysis were: sensitivity 0.21 pg/mg, intra-assay variability 5.4%, inter-assay variability 9.6%, specificity (%): cortisol 100; corticosterone 1.8; aldosterone <0.02. T-student test was used; statistical significance was set at $p < 0.05$.

Microscopic evaluation: ganglia

OPERATED. DRG. 1 M. POST SURGERY (a-b)



SHAM. DRG. 1 M. POST SURGERY (c)



Light T-neurons

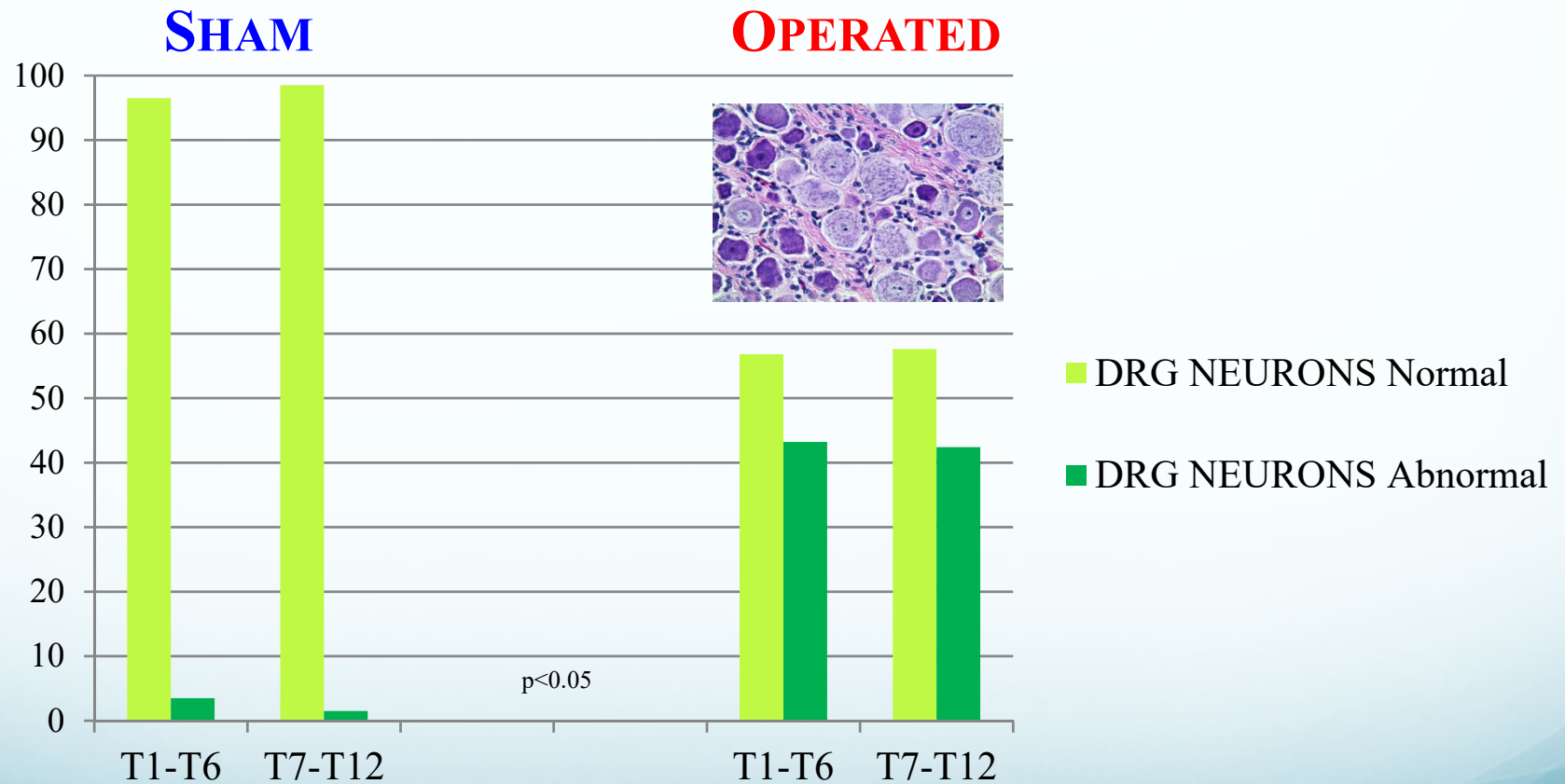
Dark T-neurons

Picnotic nucleus

Condensation of Nissl substance

Perineuronal saltellitis

Microscopic evaluation: ganglia



Conclusions

- Thoracic arthrodesis in growing rabbits induces significant changes
- **NOT ONLY** thoracic dimensions are modified

Conclusions

- *Thoracic width* increases **more** than depth
- *Thoracic kyphosis* decreases
- *Sternum* grows less
- *T1-T12 distance* is reduced
- **Thoracic cage becomes flat and elliptical**

Conclusions

- Vertebral body growth cartilage is altered
- Rib cartilage shows sign of degeneration
- Clinical and histological changes becomes more evident with time

Conclusions

- *Lungs and heart growth is reduced*
- Both heart and lungs are reduced in weight and volume
- *Respiratory function is affected*, as showed by blood gas analysis and confirmed by histology
- *Cardiac function is preserved*, as showed by both echo-cardio-color Doppler and histological findings

Conclusions

- *Hormonal profile is altered:* irregular ovulation and increased cortisol levels
- *Degeneration* of Pseudounipolar Dorsal Root Ganglia is frequent
- Diaphragm and intercostal muscles are spared

Take home message

- *Spinal arthrodesis has significant effects on many organs, not only intra-thoracic*
- *TIS induced by precocious arthrodesis is a more complex process than previously reported*

