Quantifying the Thoracic Deformity in Early-Onset Scoliosis – The Spinal Penetration Index

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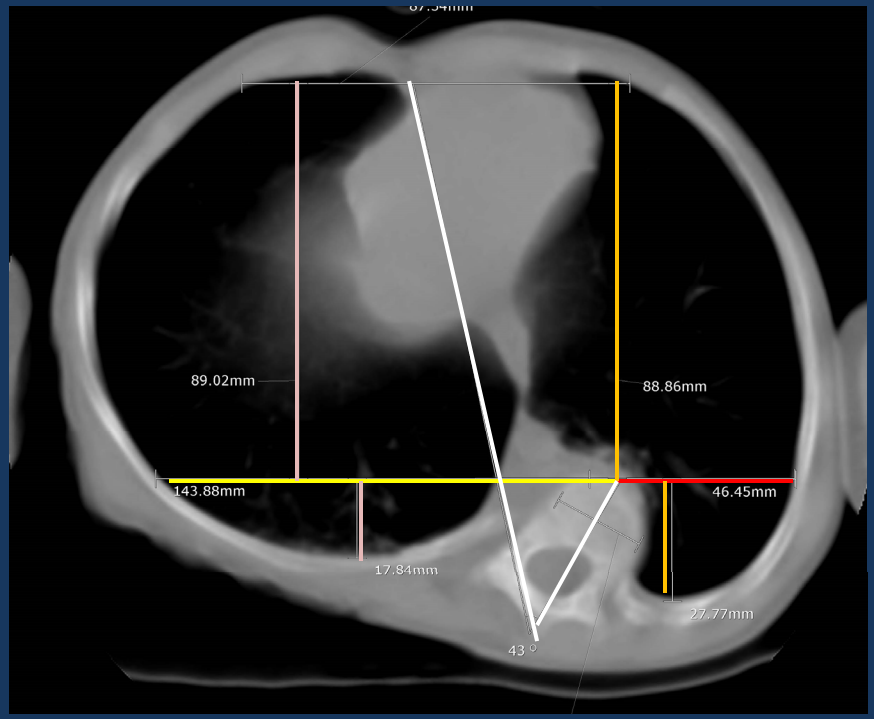
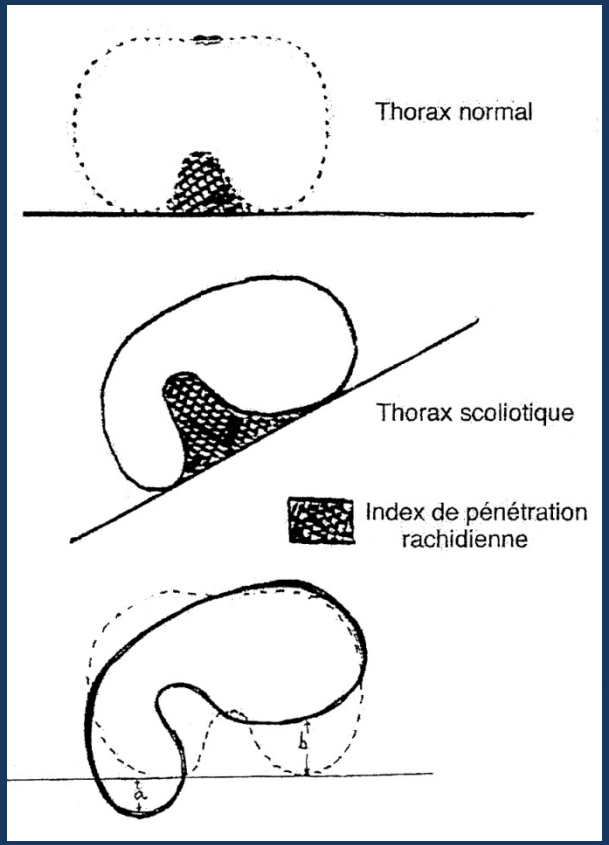
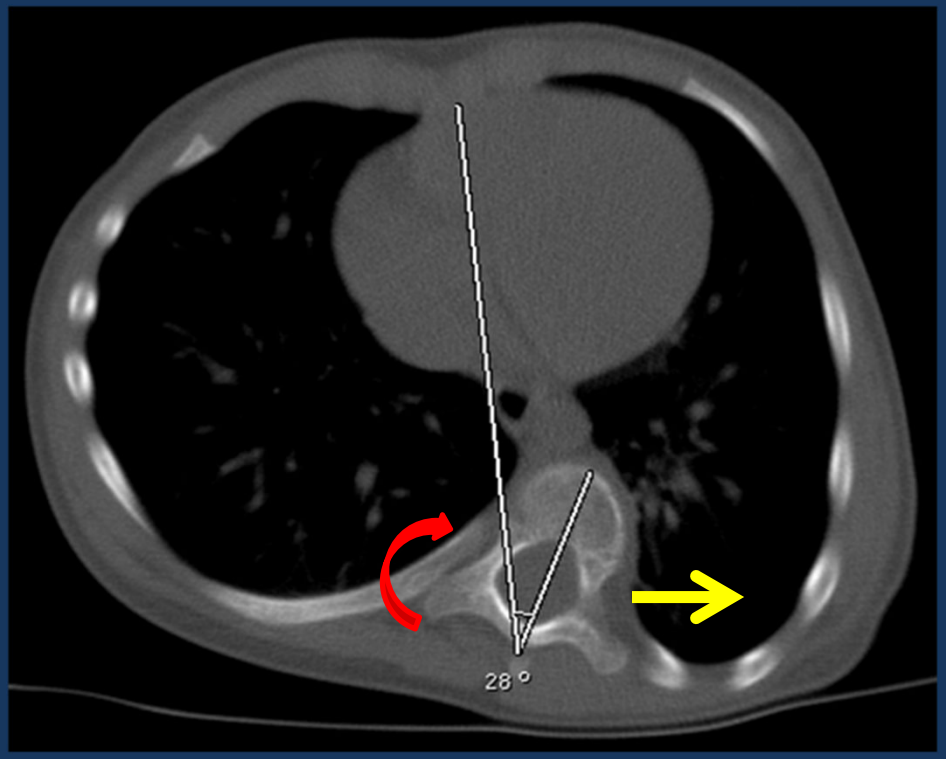


Dubousset 2002 – Penetration Index

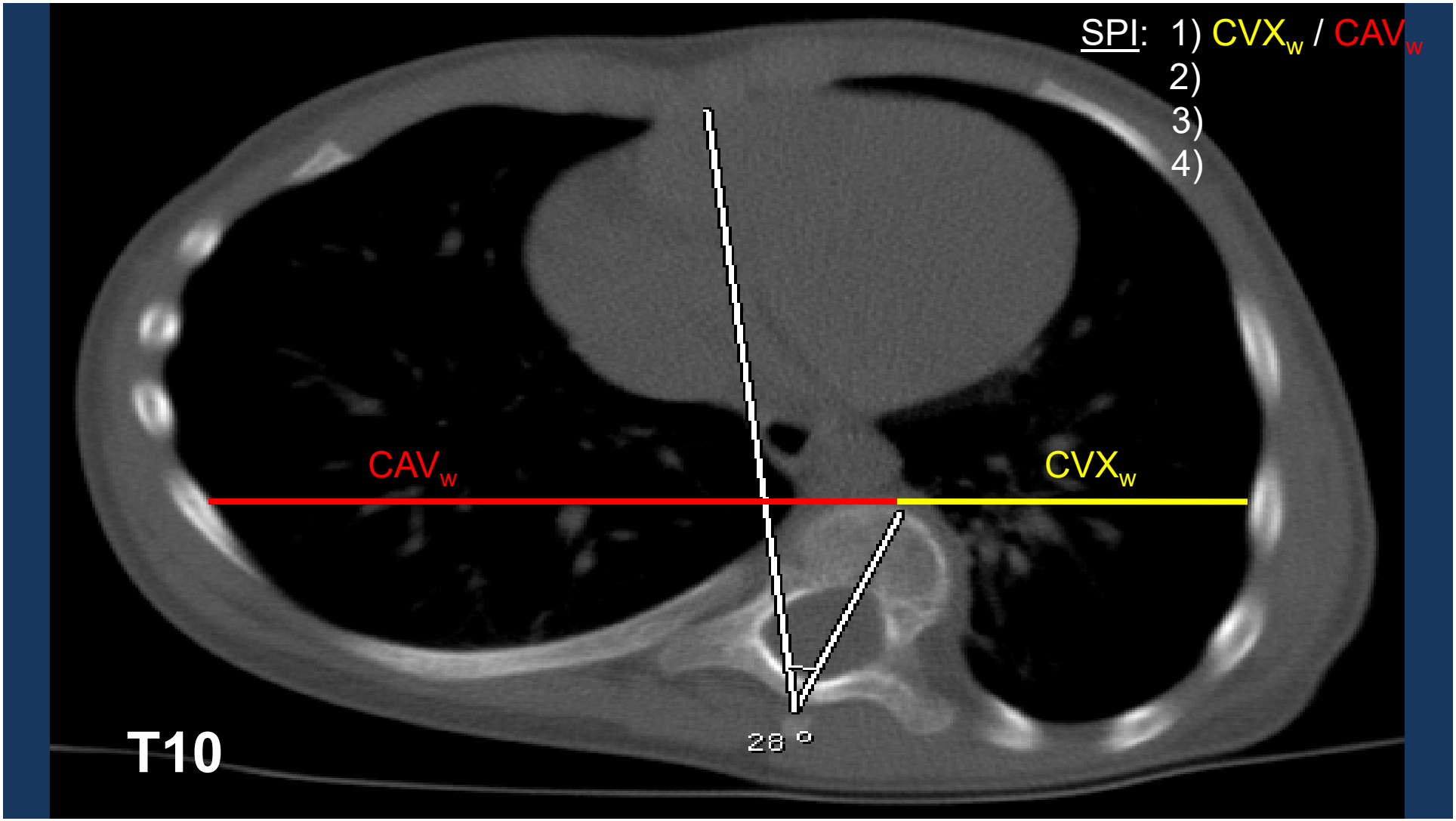
- Described by Dubousset in 2002, and termed ‘Spinal Penetration Index,’ as an apical rotation and lateral displacement of the spine into the convex hemithorax
- Subjective - Unable to quantify

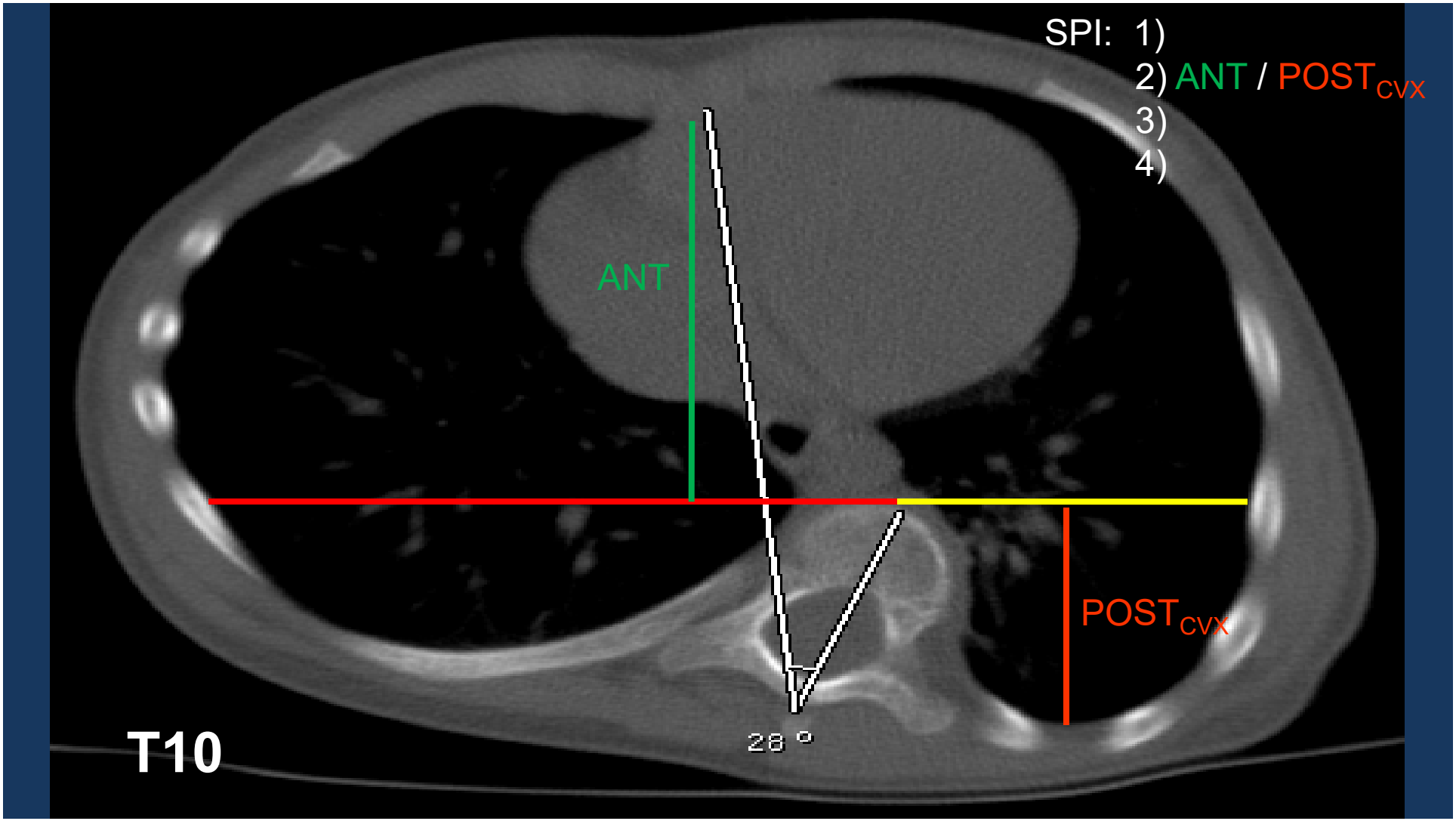


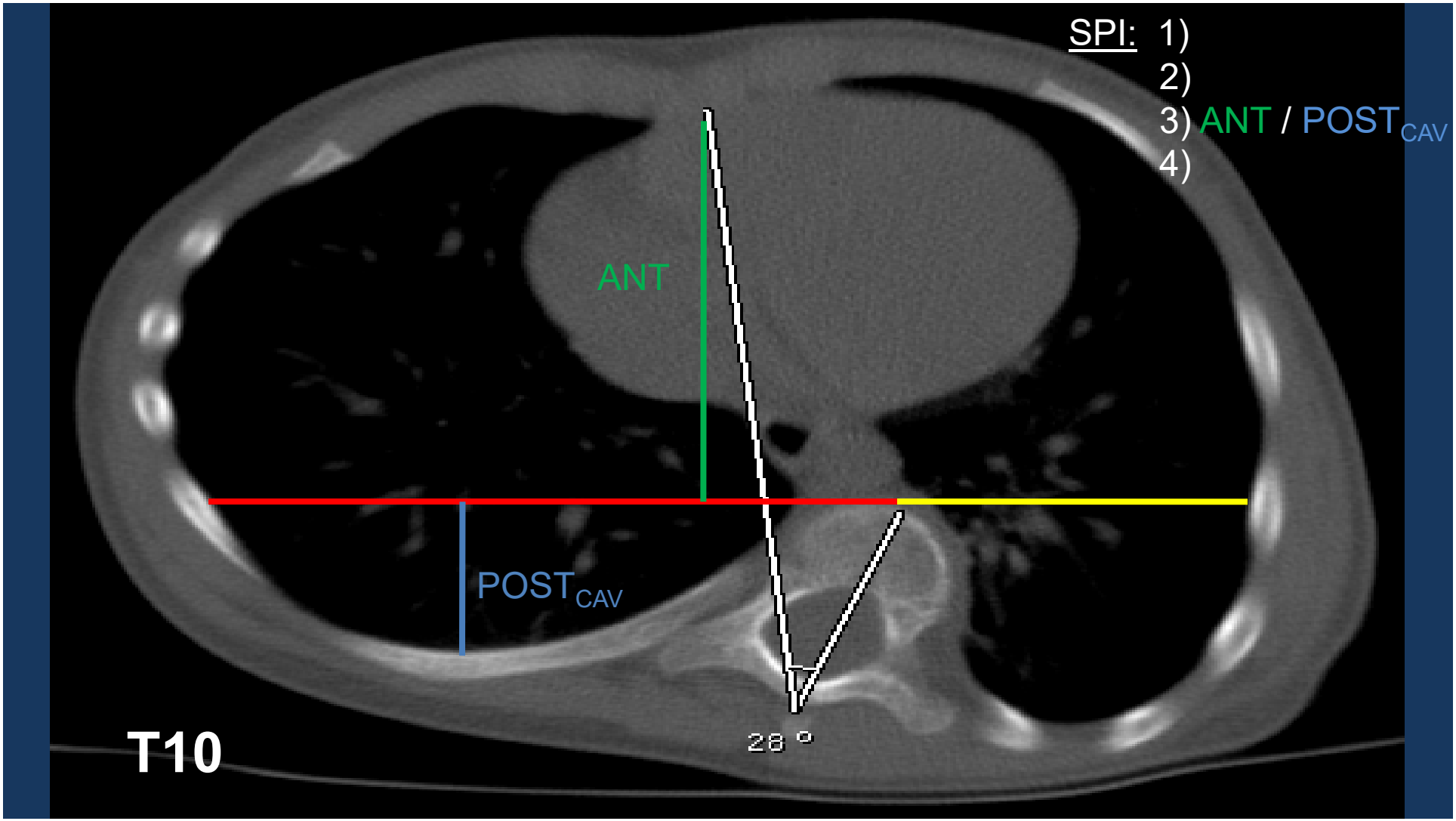
‘The Spinal Penetration Index’

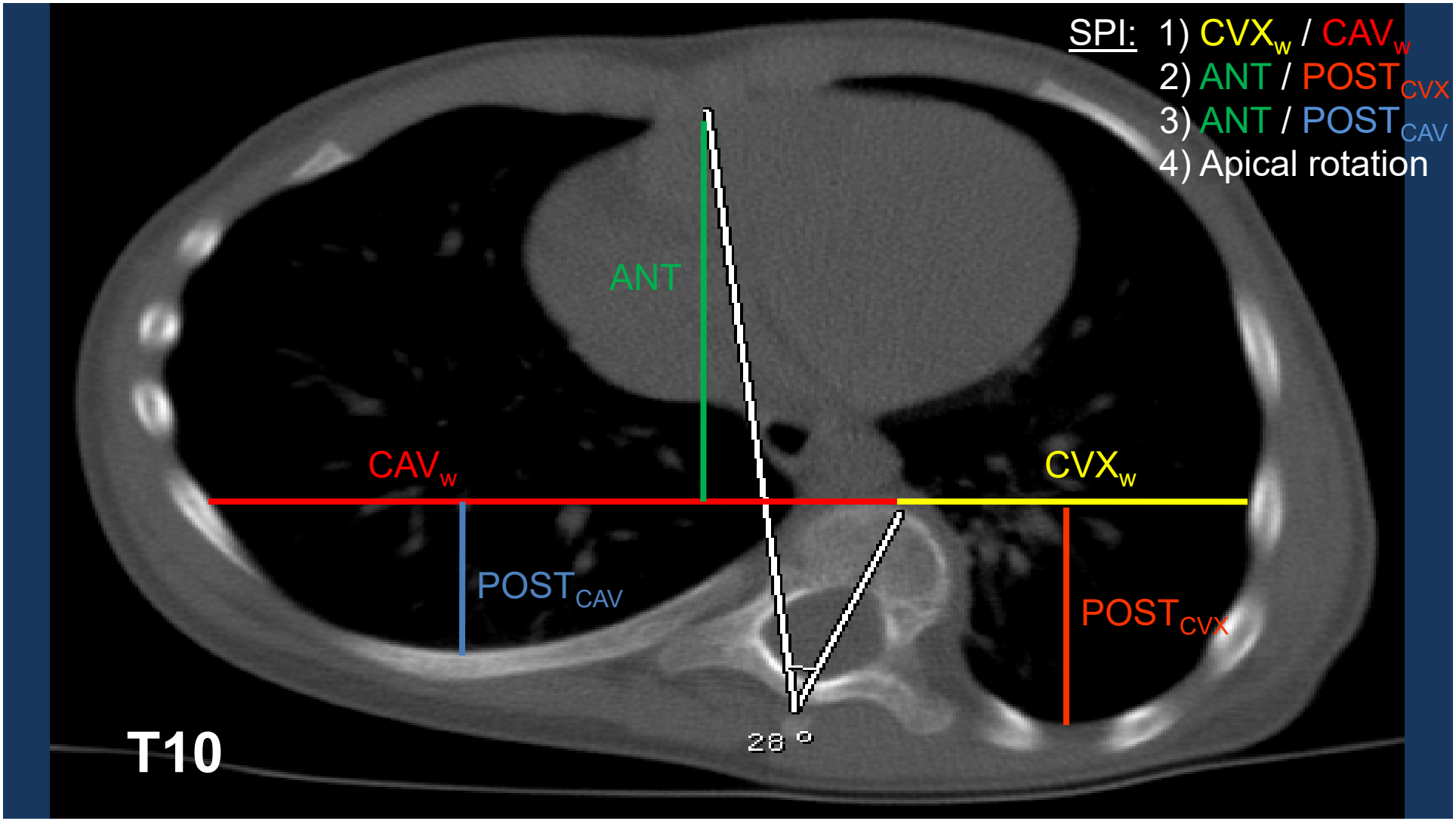


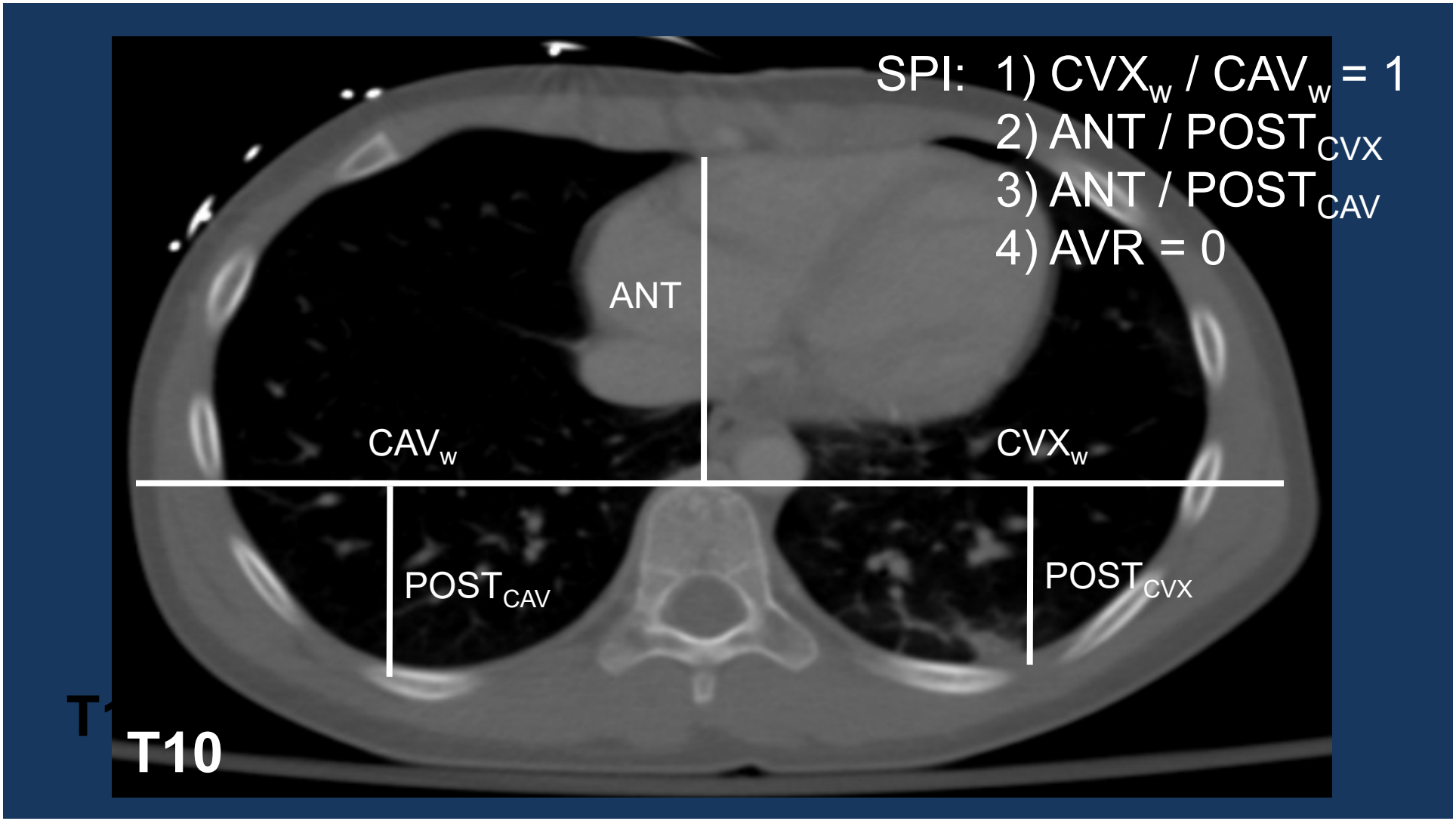
- Penetration of spine into convex hemithorax – ratio = apical vertebral translation
- Anterior – posterior dimensions of the concave and convex hemithoraces
- Apical vertebral rotation


SPI: 1) CVXw / CAVw
2)
3)
4)
CAVw
CVXw
28 °
T10


SPI: 1)
2) ANT / POST cvx
3)
4)
ANT
POST cvx
28 °
T10


SPI: 1)
2)
3) ANT / POST CAV
4)
ANT
POST CAV
28 °
T10


SPI: 1) CVXw / CAVw
2) ANT / POSTCVX
3) ANT / POSTCAV
4) Apical rotation
ANT
CAVw
CVXw
POSTCAV
POSTCVX
28 °
T10


SPI: 1) CVX_w / CAV_w = 1
2) ANT / $POST_{CVX}$
3) ANT / $POST_{CAV}$
4) AVR = 0
ANT
CAV_w
CVX_w
$POST_{CAV}$
$POST_{CVX}$
T10

Methods – Study Population

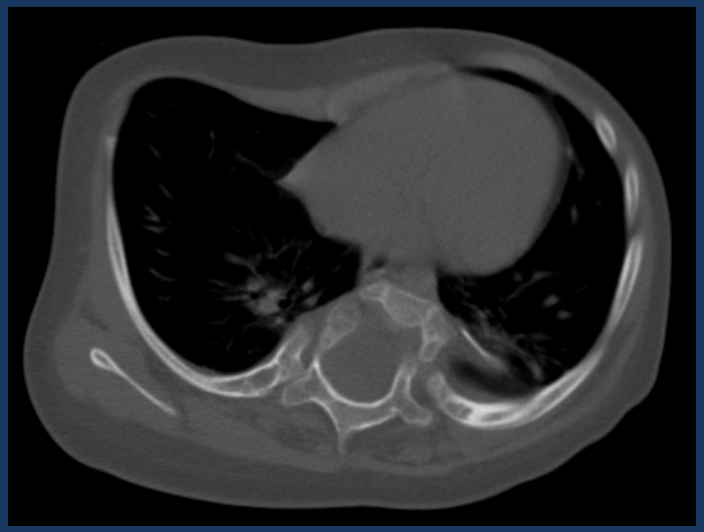
IRB-registered database of EOS patients

↓

98 patients

↓

138 Chest CTs
(lung volumes) → Congenital – 19
IIS – 31
Syndromic – 88



Methods – Control Population

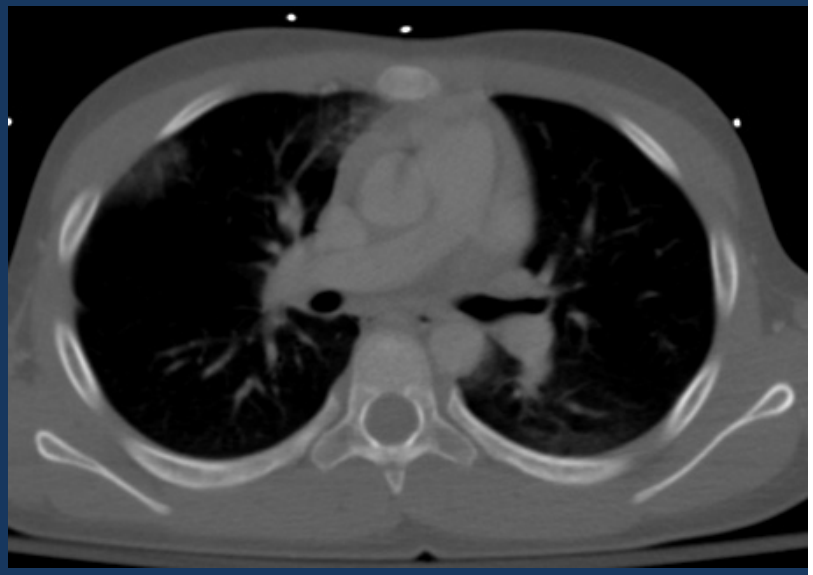
IRB-registered database at Children's Medical Center

↓

40 Normal Patients (eg. Trauma, malignancy, etc.)

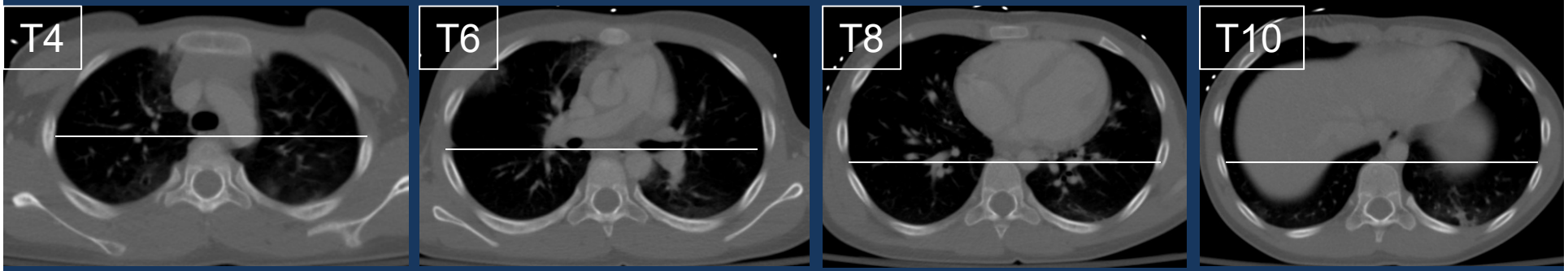
↓

SPI measured at T4, T6, T8, and T10



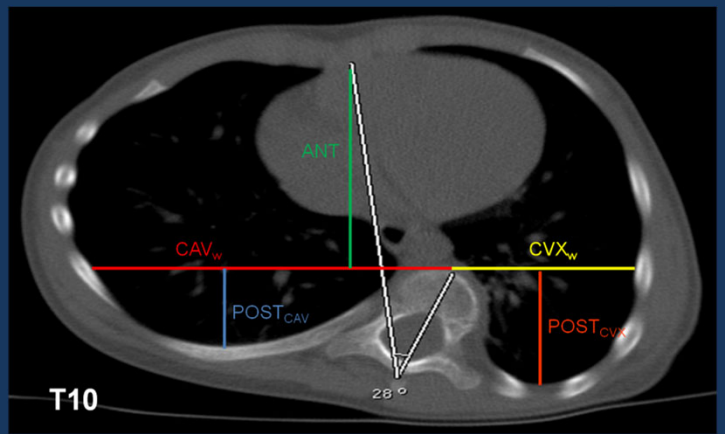
Results – Normal Values

NORMAL (40)	CVX_w / CAV_w	ANT / $POST_{CAV}$	ANT / $POST_{CVX}$	Apical Rotation
T4	0.97 (0.83 - 1.09)	1.7 (0.9 - 3.1)	1.7 (1.0 - 2.7)	-
T6	0.98 (0.88 - 1.12)	2.2 (1.5 - 3.5)	2.2 (1.6 - 3.5)	-
T8	0.97 (0.87 - 1.08)	2.4 (1.7 - 3.4)	2.3 (1.7 - 3.5)	-
T10	0.98 (0.85 - 1.09)	2.5 (1.6 - 4.5)	2.4 (1.7 - 3.8)	-
Coef. of variation	<10%*	>10%	>10%	-



Results

EOS	CVX_w / CAV_w	ANT / $POST_{CAV}$	ANT / $POST_{CVX}$	Apical Rotation
Cobb ≤ 30	0.53 (0.17 - 0.68)	2.1 (0.9 - 3.3)	2.2 (1.2 - 5.5)	13.5 (1 - 32)
Cobb > 30	0.44 (0.06 - 0.94)	3.5 (1.1 - 18.5)	2.8 (1.0 - 16.8)	30.4 (8 - 77)
p-value	0.034*	<0.0001*	0.098	<0.0001*



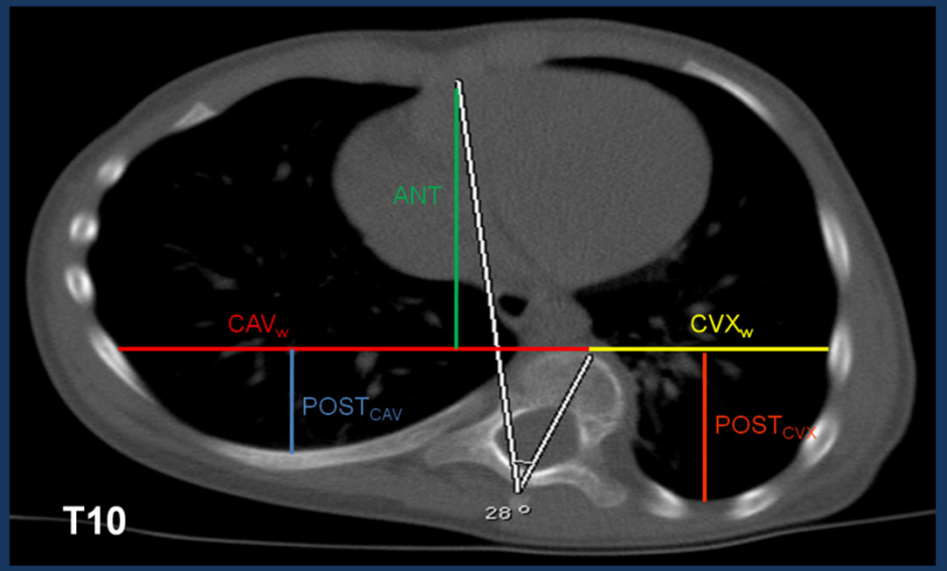
Cobb angle ↑ → Cvx/Cav ratio ↓

Ant/Post ratios ↑

(2º lordosis ?)

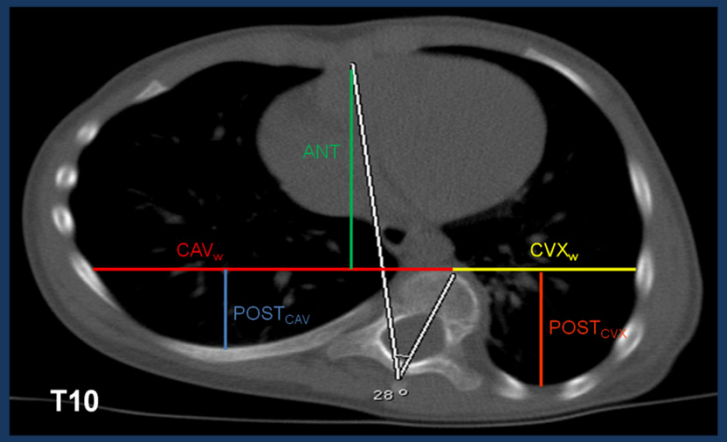
Surgical correction -> effect on SPI (proposed)

- CVX_w/CAV_w increasing toward 1
- A/P_{CAV} decreasing
- A/P_{CVX} decreasing
- Apical rotation decreasing



Results – Effect of Surgery on SPI (n=20)

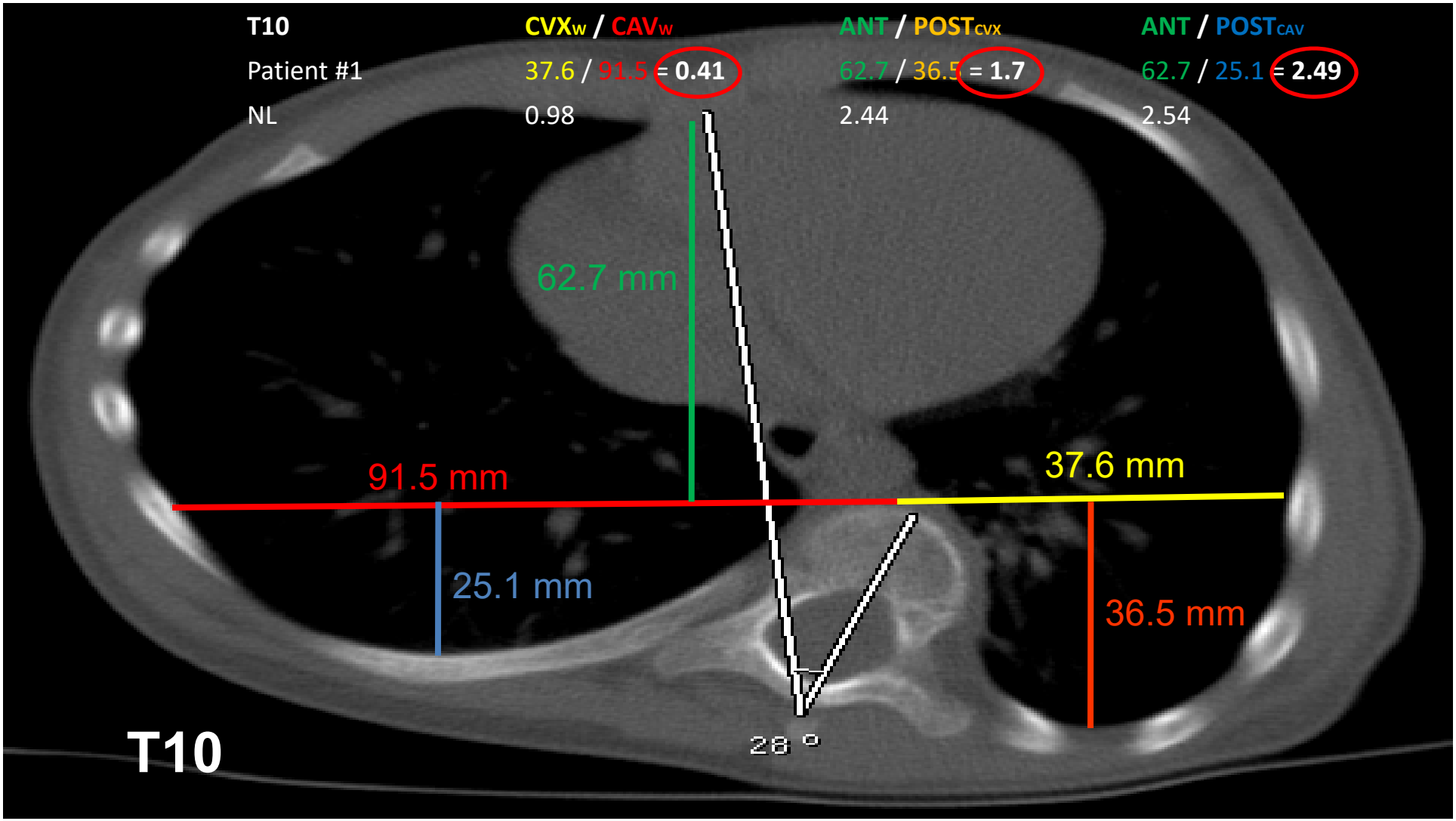
EOS	CVX_W / CAV_W	ANT / $POST_{CAV}$	ANT / $POST_{CVX}$	Apical Rotation
Pre-Op (20)	0.32 (0.06 - 0.59)	4.5 (1.2 - 18.5)	3.5 (1.5 - 16.8)	39.4 (10 - 77)
Post-Op (20)	0.35 (0.11 - 0.72)	4.4 (1.2 - 13.1)	3.0 (1.3 - 10.4)	40.7 (2 - 67)
p-value	0.997	0.687	0.425	0.585



Surgery -> No effect on SPI (entire group)

Effect of different constructs on SPI change postop

	Cvx/Cav	A/P cvx	A/P cav	Apex rot
Spine-spine n=6	No change	No change	No change	No change
Spine-rib n=9	No change	No change	No change	No change
Spine-spine w/apical cntrl n=5	.42 -> .65	3.88 -> 2.57	3.11 -> 3.52	39^{o} -> 35^{o}


T10
CVXW / CAVW
ANT / POSTCVX
ANT / POSTCAV
Patient #1
37.6 / 91.5 = 0.41
62.7 / 36.5 = 1.7
62.7 / 25.1 = 2.49
NL
0.98
2.44
2.54
62.7 mm
91.5 mm
37.6 mm
25.1 mm
36.5 mm
28 °
T10

T10

Patient #2

NL

CVX_W / CAV_W

13.0 / 81.5 = **0.16**

0.98

ANT / $POST_{CVX}$

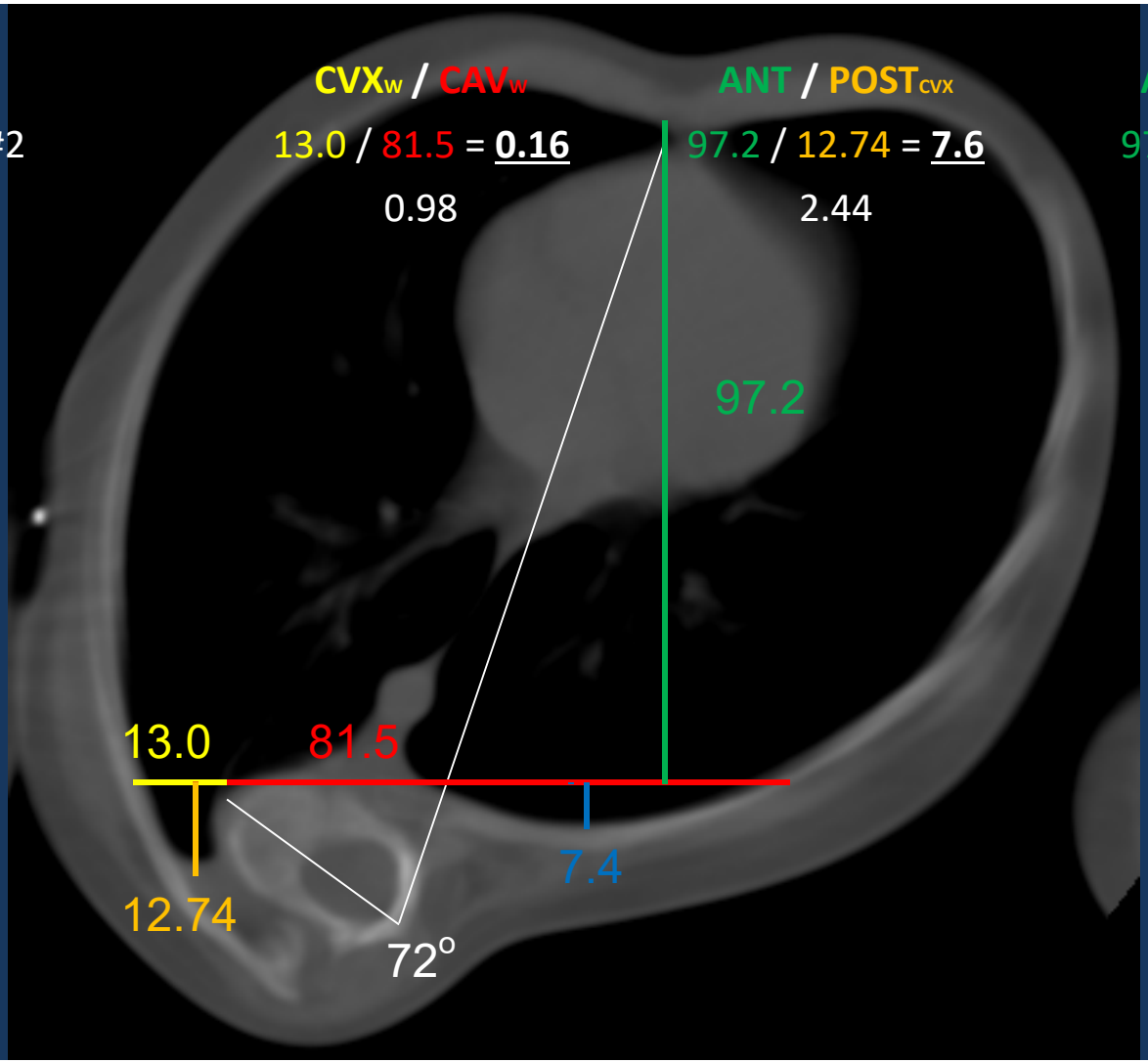
97.2 / 12.74 = **7.6**

2.44

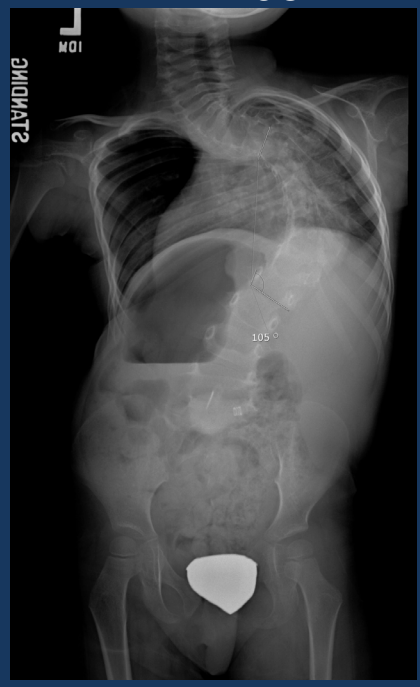
ANT / $POST_{CAV}$

97.2 / 7.4 = **13.1**

2.54



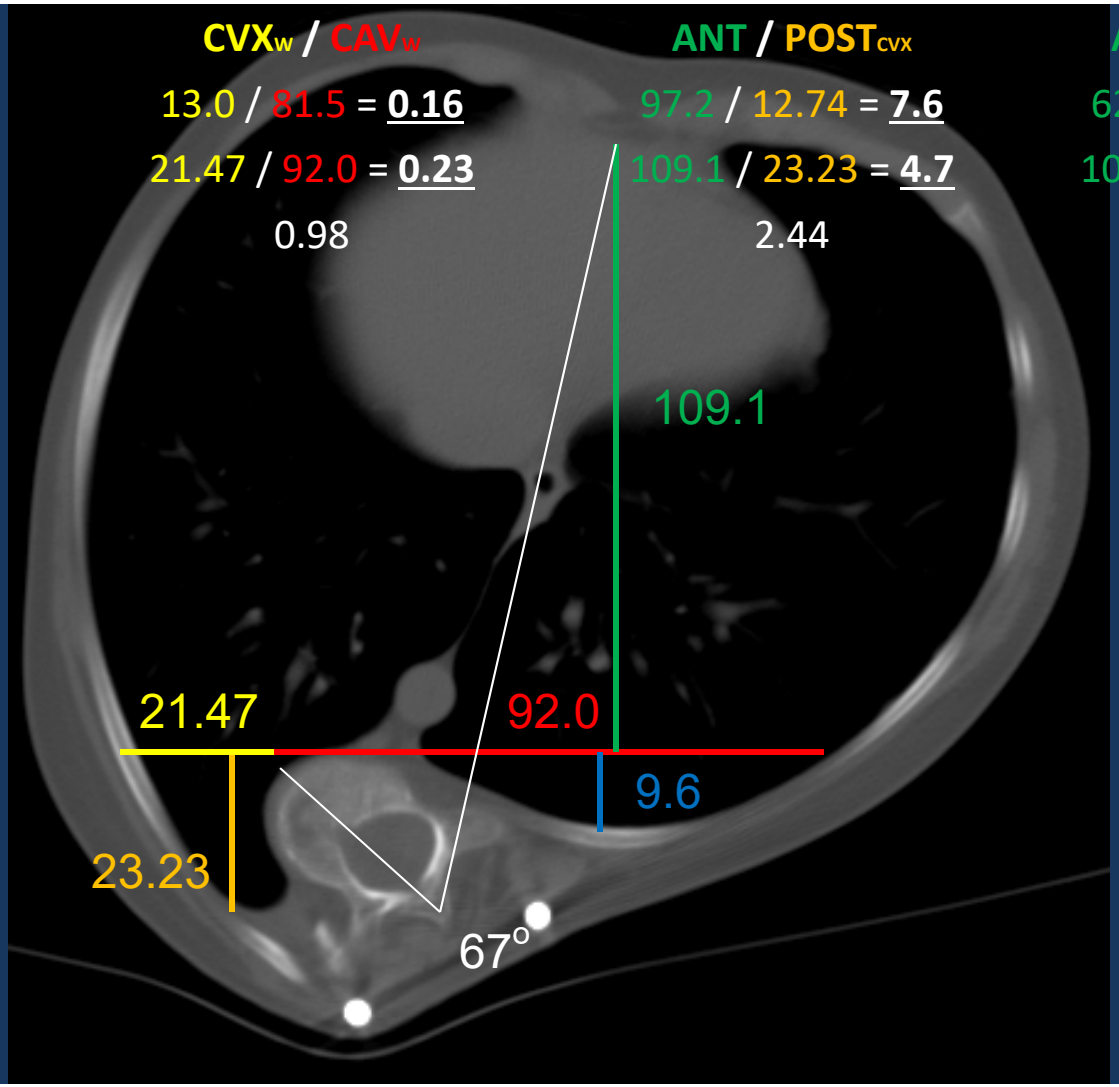
105°

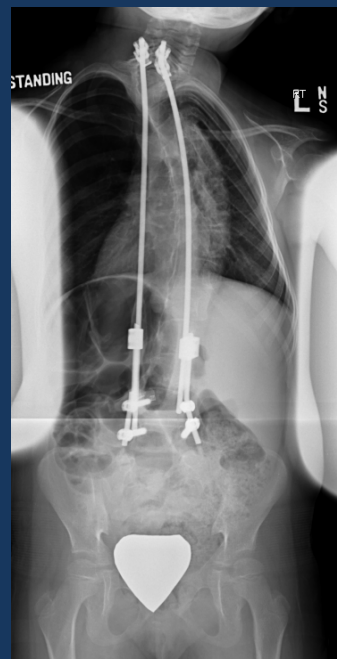


T10	CVX_w / CAV_w	ANT / $POST_{CVX}$	ANT / $POST_{CAV}$
Patient #2 – PreOp	13.0 / 81.5 = **0.16**	97.2 / 12.74 = **7.6**	62.7 / 7.4 = **13.1**
Patient #2 - PostOp	21.47 / 92.0 = **0.23**	109.1 / 23.23 = **4.7**	109.1 / 9.6 = **11.3**
NL	0.98	2.44	2.54

AVR pre 72°
post 67°

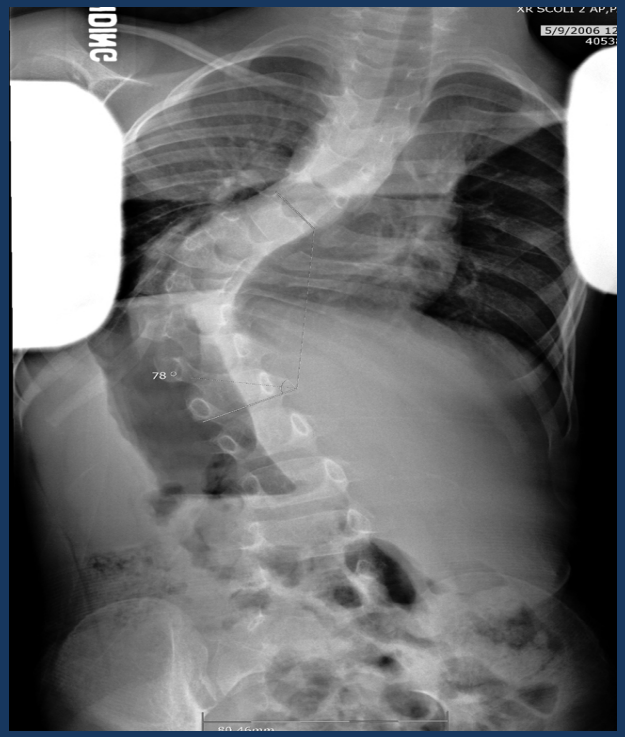
2° Pure distraction

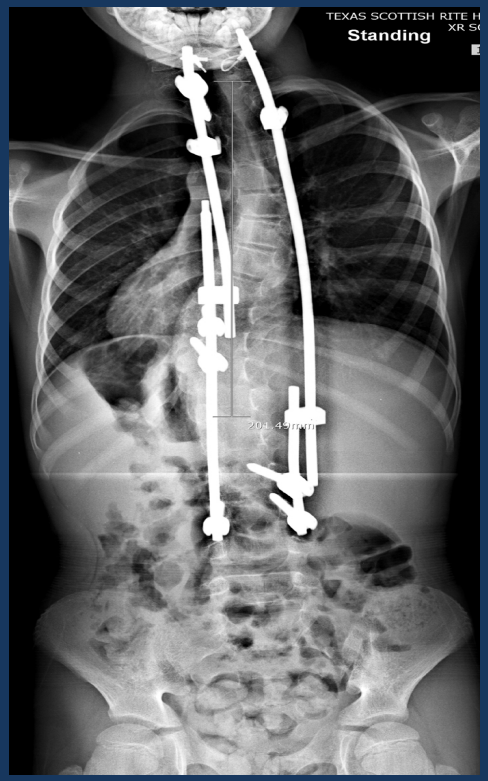


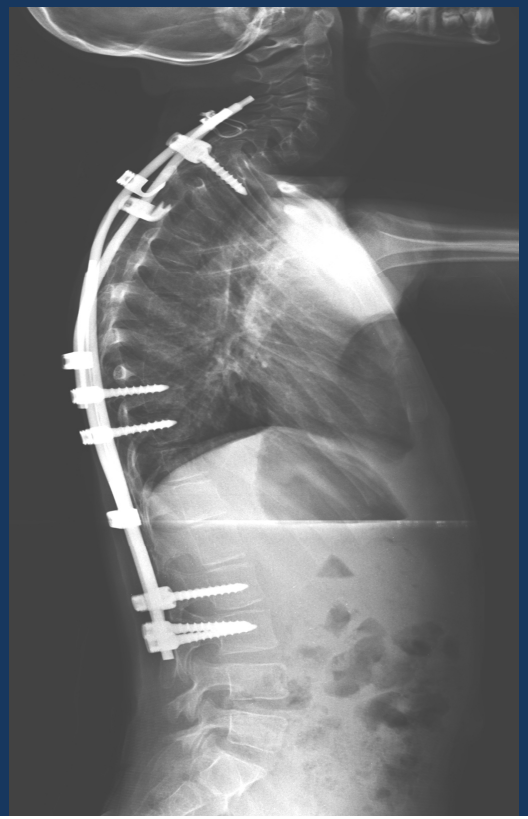


Serial lengthening + apical translation correction

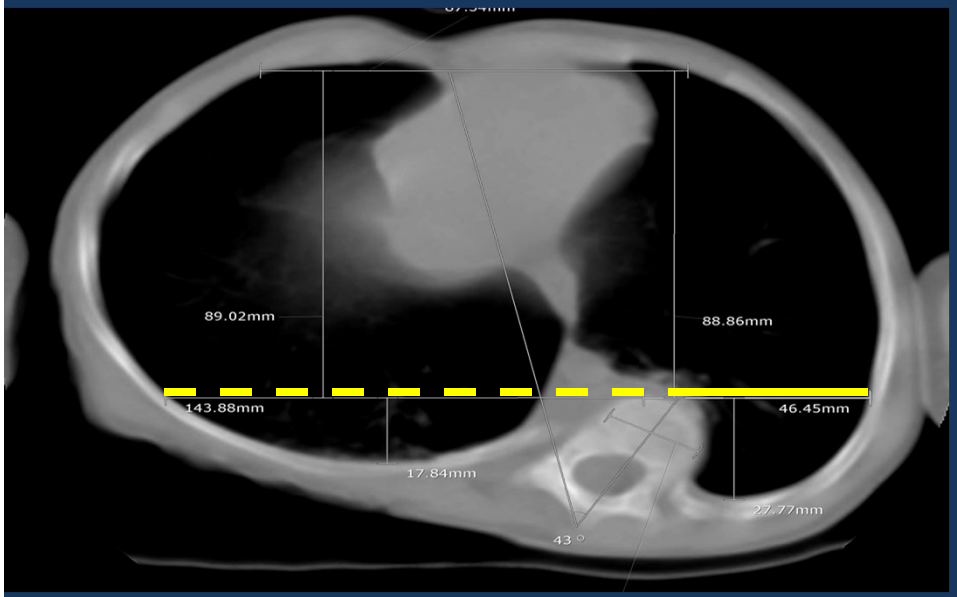
4 yr postop







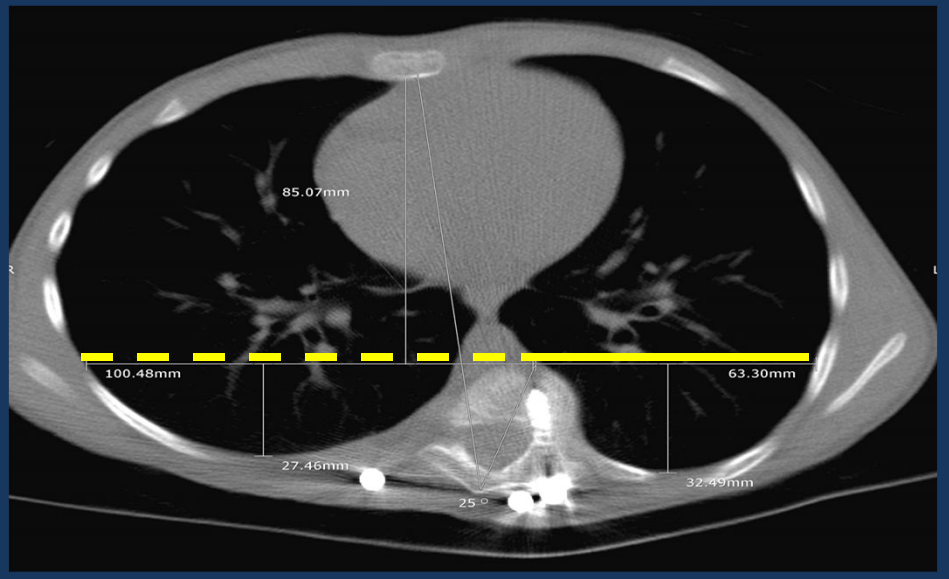
Preop



SPI = Cvx/Cav = .32 ←
A/Pcav =89/17.8 =5
A/Pcvx=88.9/27.8=3.2
AVR=43°

Followup

SPI = .63 ←
A/Pcav =3.1
A/Pcvx=2.6
AVR=25°



Discussion

1. Quantifies endothoracic deformity in 3 planes
2. Better characterization of correction achieved

Limitations

1. Small # pre-/postop patients
2. Significant variation A/P plane in normals
3. Requires CT scan

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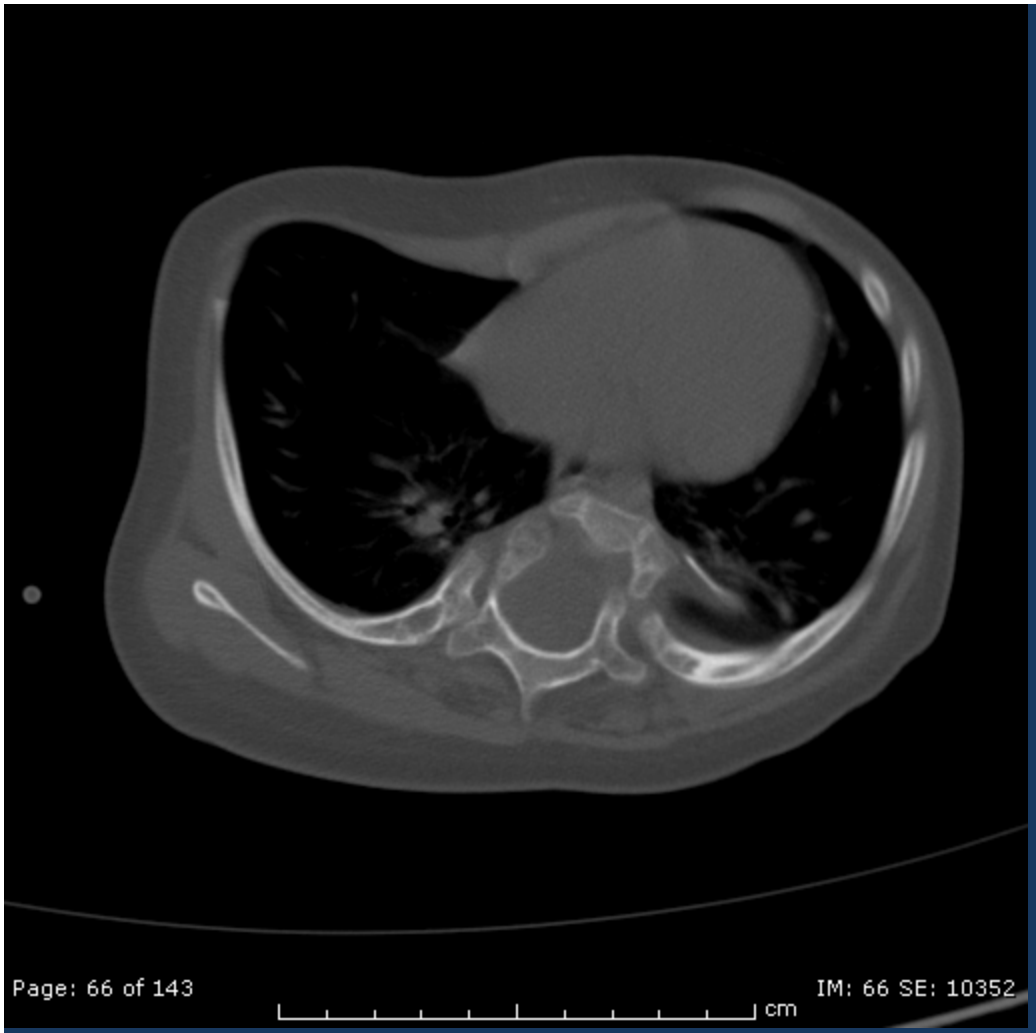
Thank you

THANKS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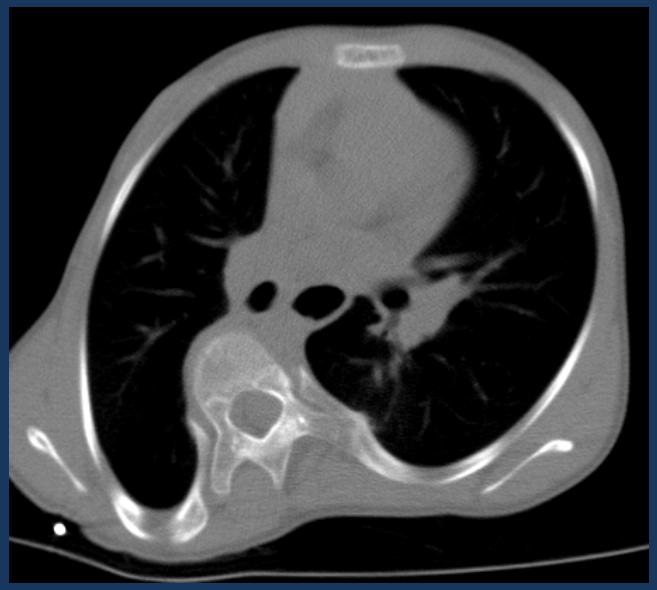
Background

- EOS results in significant thoracic deformity that adversely affects pulmonary function



Muirhead A *JBJS Br* 1985
Branthwaite MA *Br J Dis Chst* 1986
Pehrsson *Spine* 1992

Background

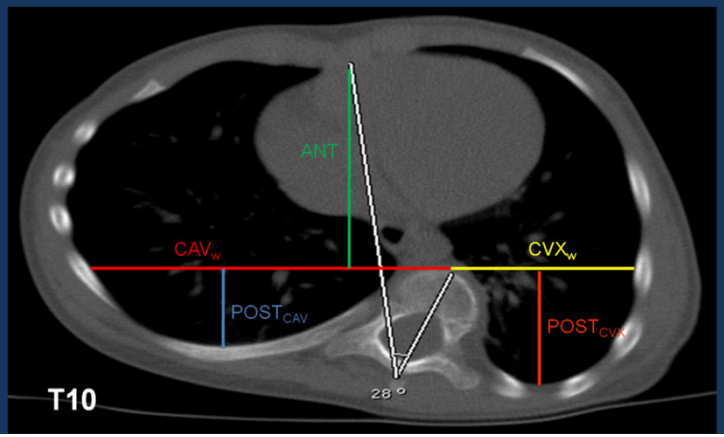
- Traditional measurements of spinal deformity fail to fully assess the 3D chest deformity
  - Cobb
  - Thoracic height
  - Thoracic width
- Our ability to accurately assess pulmonary function in EOS patients and link that to current measurements is limited

Purpose

- To quantify the amount of endothoracic deformity in EOS
  - Improved ability to follow deformity over time
  - Lead to better indications for surgical intervention
  - A metric that includes both the spine and chest deformity – more directly related to pulmonary function

Results – SPI related to Gender

EOS	CVX_W / CAV_W	ANT / $POST_{CAV}$	ANT / $POST_{CVX}$	Apical Rotation
Male (46)	0.45 (0.12 - 0.91)	3.30 (0.9 - 13.2)	2.9 (1.1 - 9.5)	26.0 (1 - 60)
Female (52)	0.45 (0.06 - 0.94)	3.28 (1.2 - 18.5)	2.56 (1.0 - 16.8)	30.0 (8 - 77)
p-value	0.824	0.957	0.365	0.127



Results – SPI related to Diagnosis

EOS	CVX_W / CAV_W	ANT / $POST_{CAV}$	ANT / $POST_{CVX}$	Apical Rotation
IIS	0.46 (0.06 - 0.91)	3.4 (1.2 - 13.1)	2.9 (1.3 - 16.8)	31.7 (14 - 77)
Syndrome	0.45 (0.11 - 0.68)	3.4 (1.1 - 18.5)	2.7 (1.0 - 10.6)	28.3 (1 - 73)
Congenital	0.44 (0.17 - 0.94)	2.5 (0.9 - 13.1)	2.2 (1.0 - 10.4)	22.4 (10 - 43)
p-value	0.970	0.335	0.395	0.119