Automatic Rib cage Unfolding with CT Cylindrical Projection Reformat in Polytraumatized Patients for Rib Fracture Detection and Characterization

Ayla Urbaneja (MD), Jacques De Verbizier (MD), Anne-Sophie Formery (MD), Catalina Tobon-Gomez (PhD), Lionel Nace (MD), Alain Blum (MD, PhD), Pedro Augusto Gondim Teixeira (MD, PhD)

Objectives and Methods

- **Objectives** : To assess the diagnostic performance and evaluation time of CT with unfolded cylindrical projection (UCP) for rib fracture detection and characterization.

- **Méthods** :

  - Retrospective analysis of CT images of 57 consecutive polytrauma patients (60 selected, 3 excluded) by 2 readers (2 radiologists) in 2 readout sessions performed at least one month apart:
    - ✓ UCP images
    - ✓ Conventional reformats

  - From November 2016 to January 2017

  - Analysis :
    - ✓ Fracture or not
    - ✓ Displaced or not
    - ✓ Single or multiple

  - Evaluation was timed

Example of an image obtained by UCP
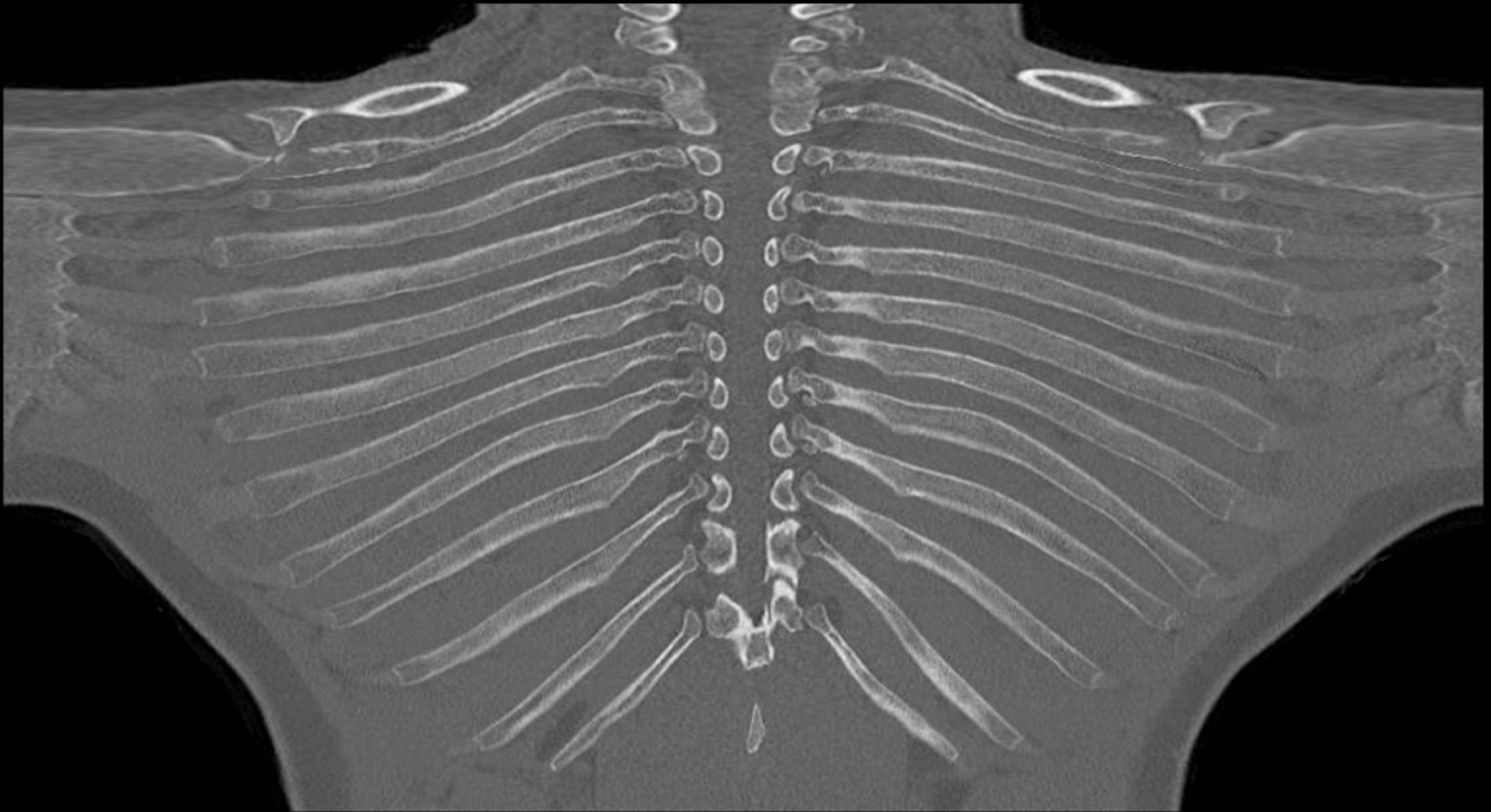
Rib cage post-processing by rib UCP with a bone window of a polytraumatized patient

In this image all 24 ribs are displayed entirely in a coronal plane.
In the center : the dorsal column and laterally : the lateral extremities of the sternum

Results : comparison between the diagnostic performances of the conventional reformat and UCP analysis

	Conventional Reformat		UCP analysis	
	Reader 1	Reader 2	Reader 1	Reader 2
True positive	121	140	125	161
True negative	1185	1186	1169	1153
False positive	6	5	22	38
False negative	56	37	52	16
Sensitivity	68.4%	79.1%	70.6%	91.0%
Specificity	95.5%	99.6%	98.2%	96.8%
PPV	95.3%	96.6%	85%	80.1%
NPV	95.5%	97.0%	95.7%	98.6%
Mean Evaluation time*	1 min 39s (± 1m06s)	6 min 09s (± 1m34s)	1 min 12s (± 43 s)	2 min 48s (± 1m00s)

PPV : Positive Predictive Value
NPV: Negative Predictive Value
* Data expressed in minutes (m) and seconds (s)

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Mean reduction in evaluation time :
27% to 55%

p = 0.01 to
p < 0.001

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Kappa :
- Conventional reformats : 0.77
- UCP : 0.71

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Example of rib fractures
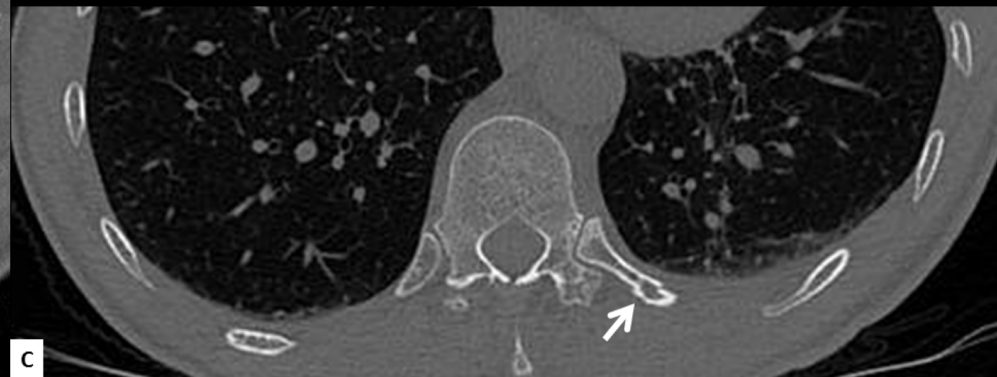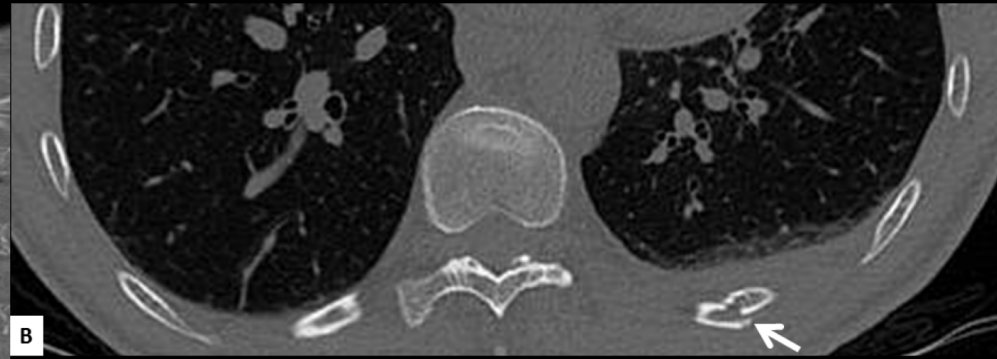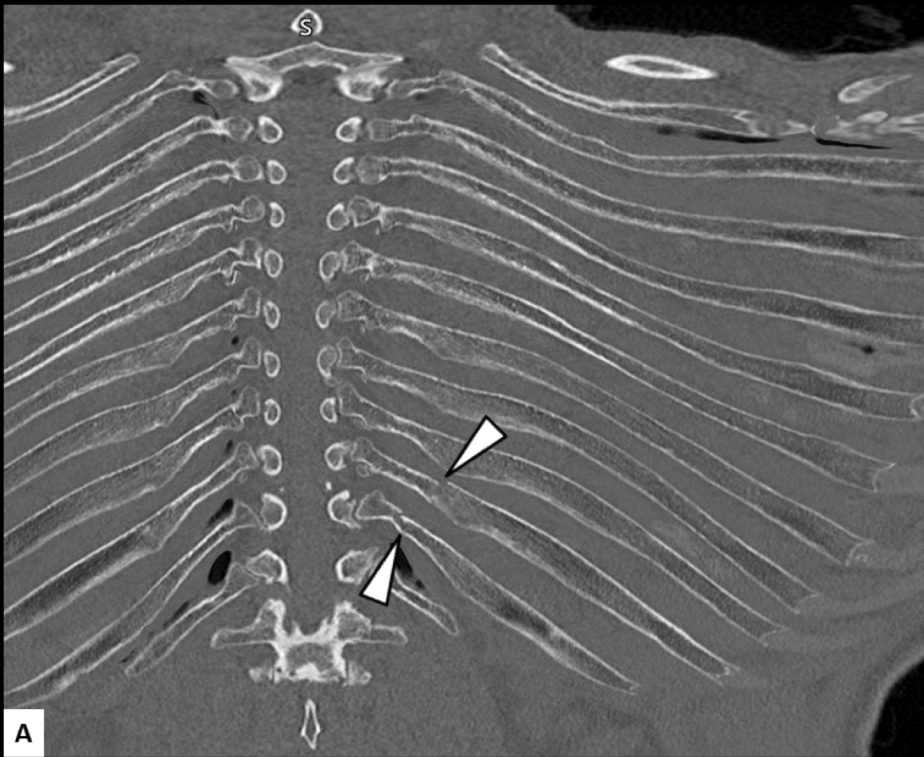
A) UCP image: single non-displaced fracture of the 10th and the 11th left ribs (arrow heads)

B) C) Axial CT images of the same patient demonstrating the corresponding fractures of the 10th and 11th respectively (thin arrows)

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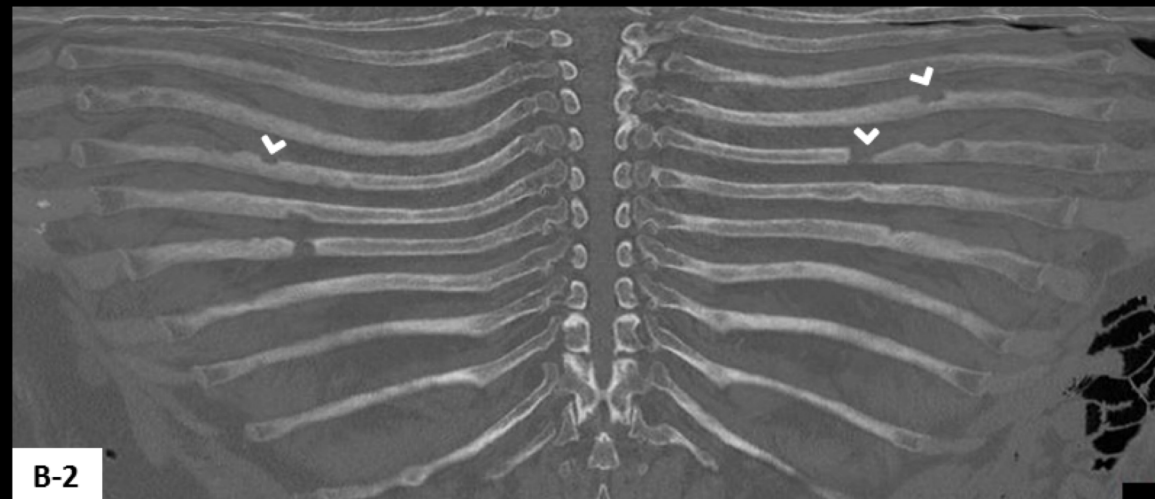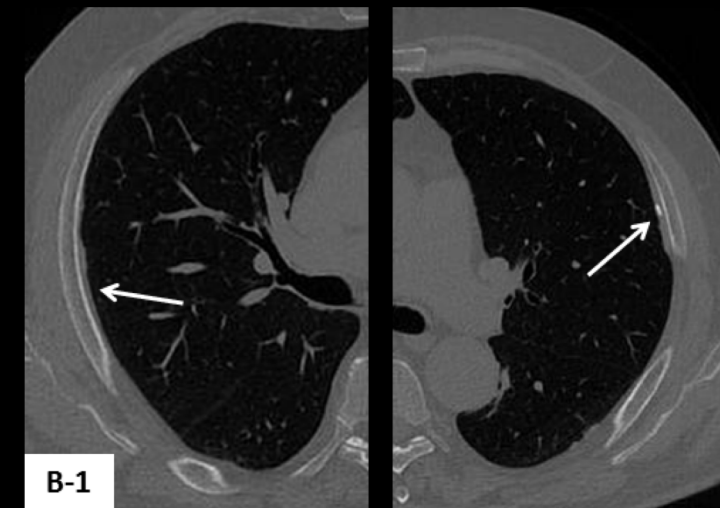PPV : Positive Predictive Value
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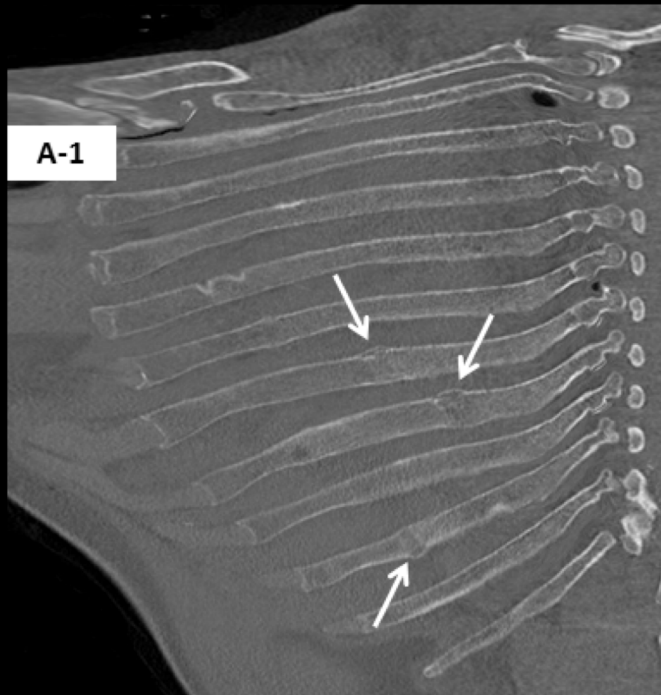Examples algorithm related artifacts with UCP
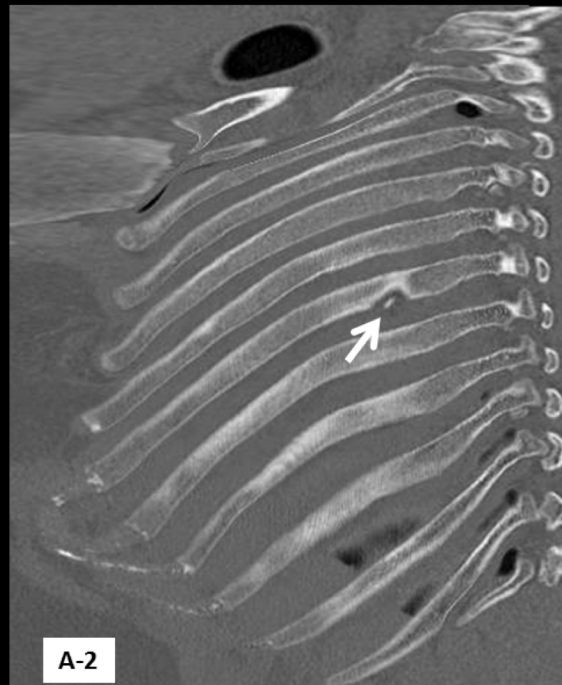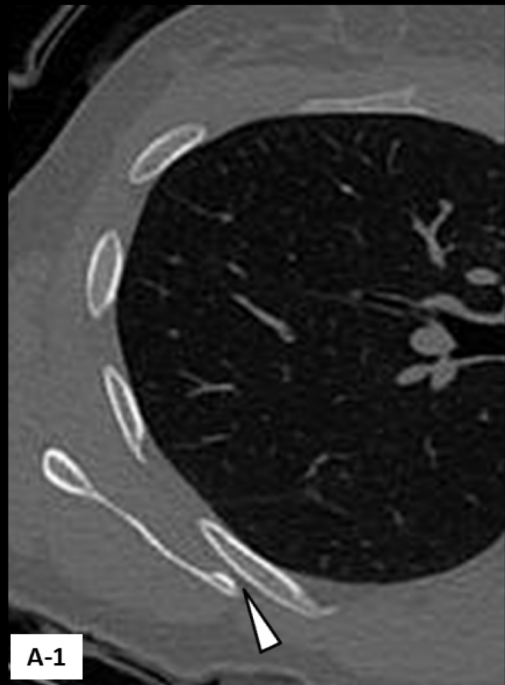
A) Close proximity with the inferior angle of the scapula generated contour abnormalities in the 6th right rib
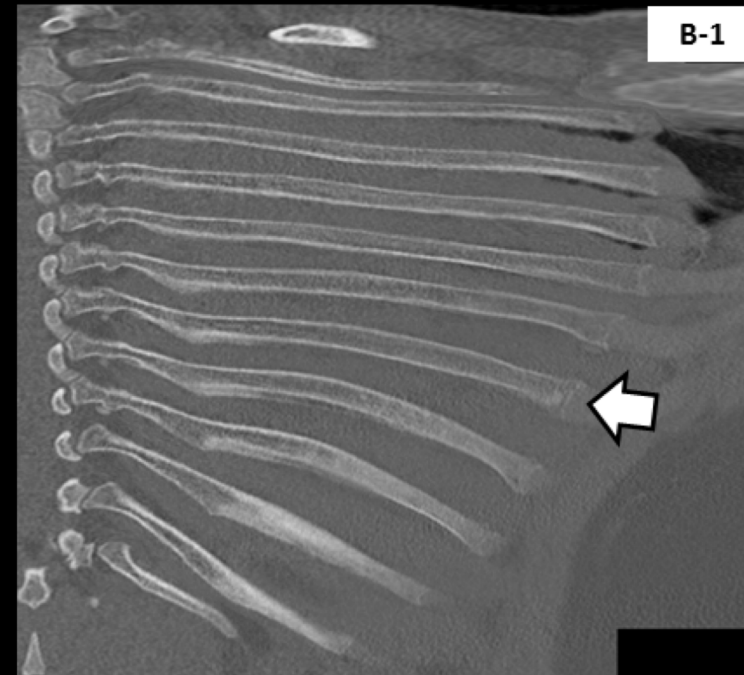
B) Pleural calcifications generated contour abnormalities with the adjacent ribs on UCP images
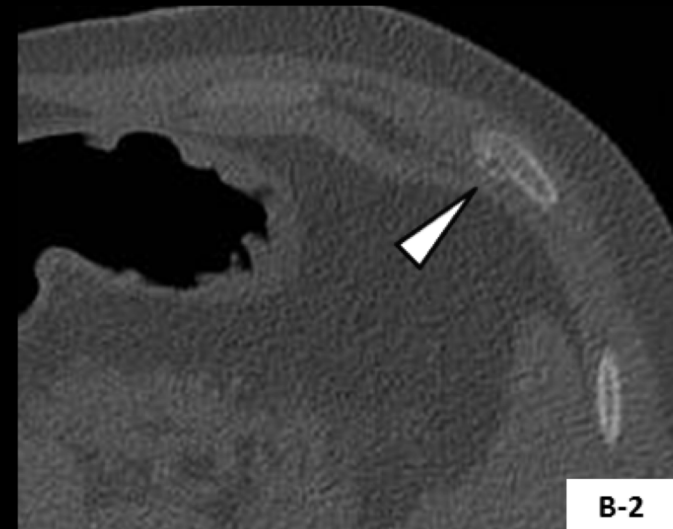
False positive and negative examples with UCP images

A) False positive: Rib contour abnormalities seen in the 7th, 8th and 10th right ribs corresponded to old fractures on conventional sagittal reformats

B) False negative: hair-like fracture of the 7th left rib not diagnosed by readers on the UCP view

Results : comparison between the diagnostic performances of the conventional reformat and UCP analysis

Distinction between	Conventional Reformat		UCP analysis	
	Reader 1	Reader 2	Reader 1	Reader 2
Single and multiple fractures	81%	89.3%	80.8%	88.2%
Displaced or not fractures	83.5%	97.1%	69.6%	86.3%

Limitations

- Small increase in the number of false positives compared to conventional images
- Presence of reconstruction artifacts responsible about 5% of interpretation error
- Difficulty to characterize fracture displacement

Conclusion

- UCP rib cage reformats yielded a diagnostic performance similar to that of conventional reformats for

  - the detection of rib fractures with a good reproducibility and an important reduction in evaluation time.

  - the detection of multiple fractures.