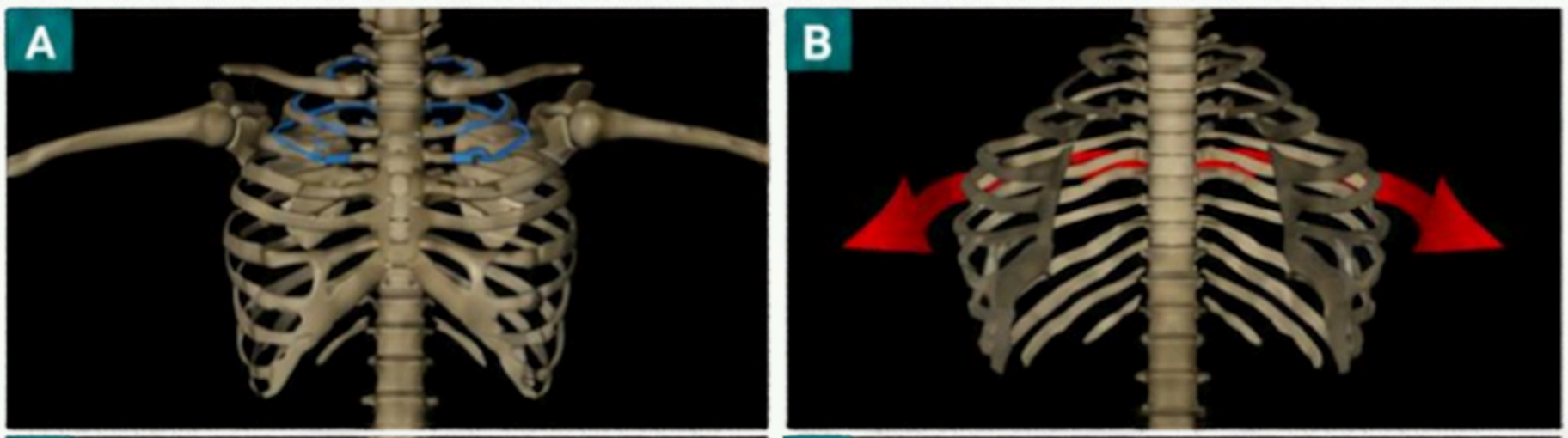
UNFOLDED RIB COMPUTED TOMOGRAPHY: A PICTORIAL REVIEW OF COMMON RIB PATHOLOGIES, CLINICAL UTILITY, AND TECHNICAL LIMITATIONS

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OBJECTIVES

To illustrate the clinical utility of unfolded rib CT (URCT) in evaluating common rib pathologies, highlight typical imaging appearances, and discuss technical limitations.

INTRODUCTION

- Unfolded rib computed tomography (URCT) reformats the curved three-dimensional rib cage into a two-dimensional linear format.
- Because the ribs follow a complex C-shaped course around the thorax, assessment on axial or multiplanar view can be difficult and time-consuming.
- URCT facilitates rapid, rib-by-rib assessment and screening for focal osseous abnormalities.

Technical Principle of URCT

1. Rib segmentation from volumetric CT data
2. Calculation of each rib's 3D centreline
3. Projection of rib volume into a straightened 2D plane

MATERIALS AND METHODS

- Retrospective review of thoracic CT examinations from 1 August 2023 to 1 August 2026 in Tseung Kwan O Hospital.
- Search performed in the radiology-information-system using keyword "rib".
- Those with rib pathologies were processed with Simens Healthineer automated rib-unfolding software.
- Representative cases on URCT were selected to illustrate spectrum of common rib conditions.

RESULTS

A total of 344 cases were identified: 191 (55.5%) traumatic, 9 (2.6%) congenital, 80 (23.3%) benign and 64 (18.6%) malignant rib conditions were acquired. URCT is able to efficiently and reliably pick up most of the rib conditions on a single panoramic images.

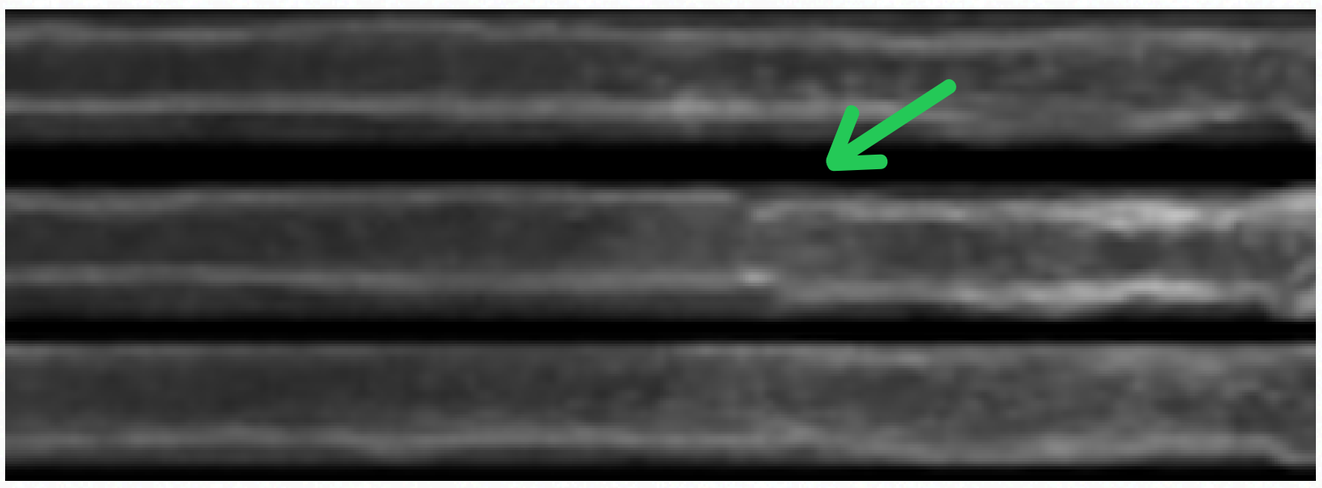
SCOPE OF REVIEW

This review covers traumatic, congenital, benign and malignant rib abnormalities, as well as the clinical advantages and technical limitations of unfolded rib computed tomography.

Pictorial Review: Traumatic and Congenital Findings

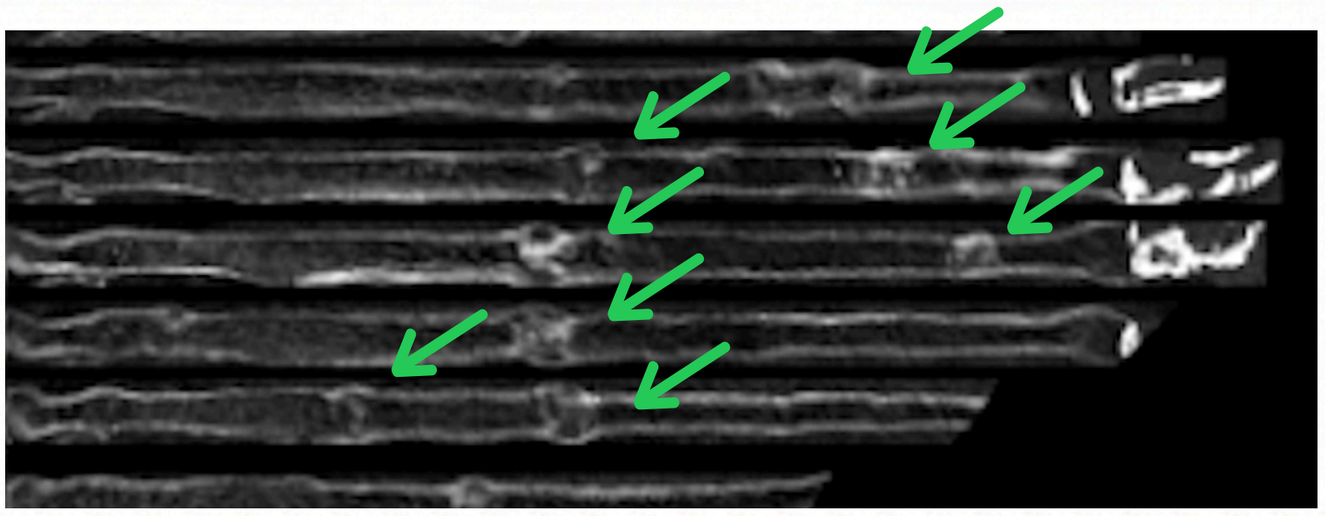
1 Acute rib fracture

- Focal cortical discontinuity, lucent line, cortical step-off, or angulation.
- May be associated with soft-tissue swelling or periosteal haematoma, which may present as irregular density along the bone margin.



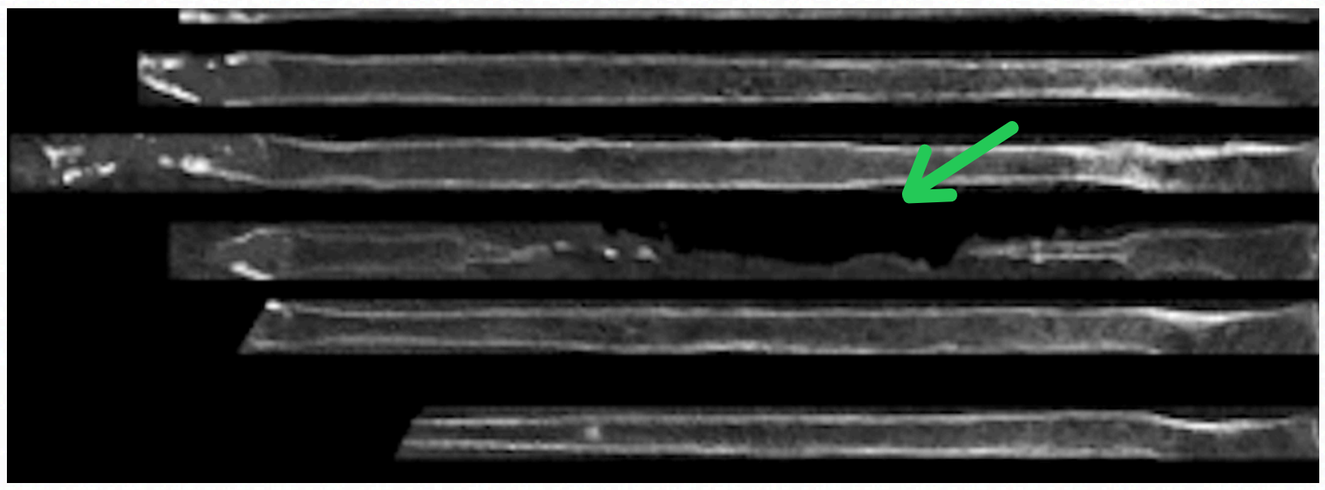
2 Old rib fracture

- Cortical irregularity, focal thickening, deformity or callus formation.
- Mature callus may produce focal expansion or irregular hyperdensity.



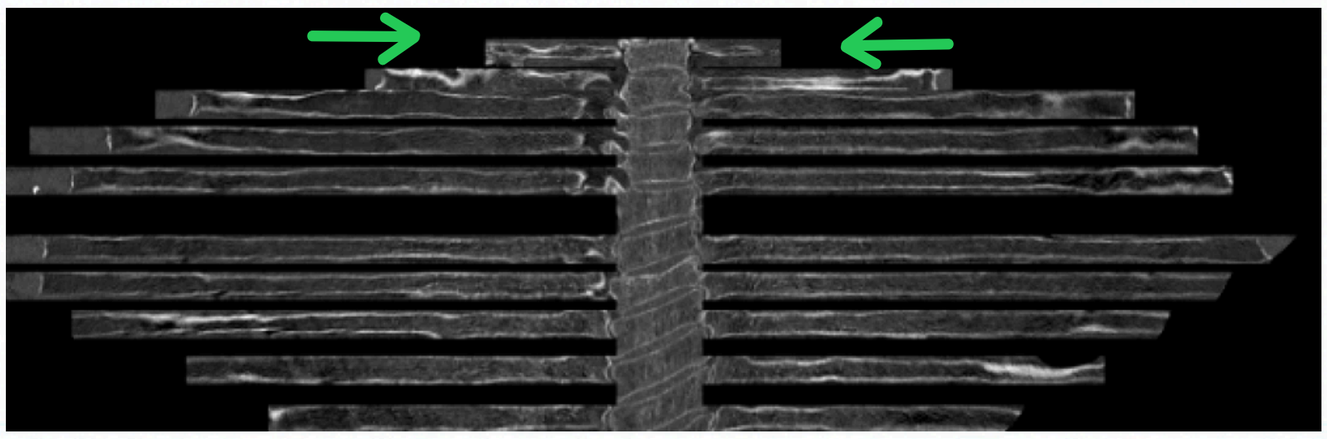
3 Hypoplastic rib

- Underdeveloped rib that is shorter or narrower than expected, often with absent or rudimentary anterior component.
- Always compare with the opposite and adjacent ribs to avoid mistaking it as an old fracture or destructive process.



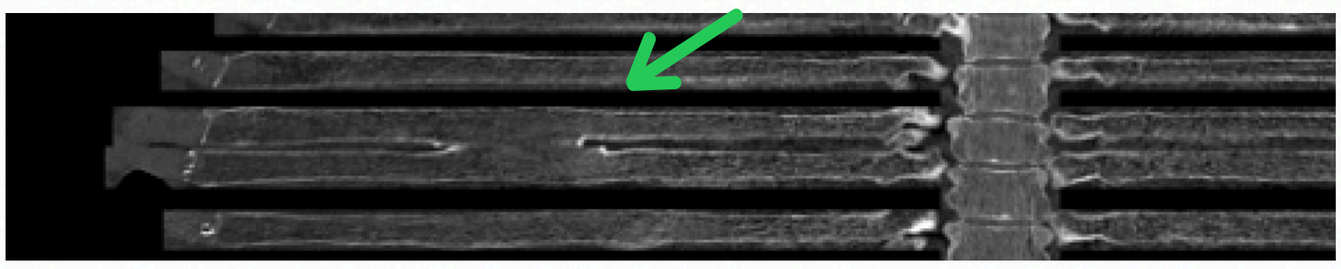
4 Cervical rib

- Accessory rib from C7, can be unilateral or bilateral, extra and often smaller bony structure superior to the first thoracic rib.
- Assess its relationship to scalene muscle and brachial plexus on axial and multiplanar images.



5 Rib fusion

- Bridging bone between adjacent ribs, commonly affecting the first and second ribs.



INTERPRETIVE NOTE:

While URCT successfully depicts a variety of congenital anomalies, the frequency of segmentation errors rises with increasing anatomical complexity. Manual correction can compensate for these errors but remains laborious and time-intensive.

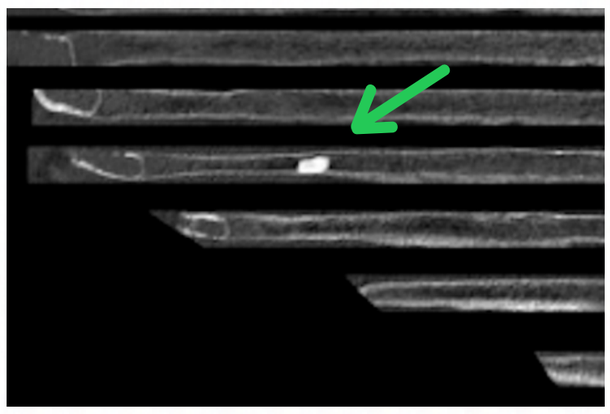
Unfolded Rib Computed Tomography: A Pictorial Review of Common Rib Pathologies, Clinical Utility, and Technical Limitations

Pictorial Review: Benign and Malignant Bone Lesions

BENIGN LESIONS

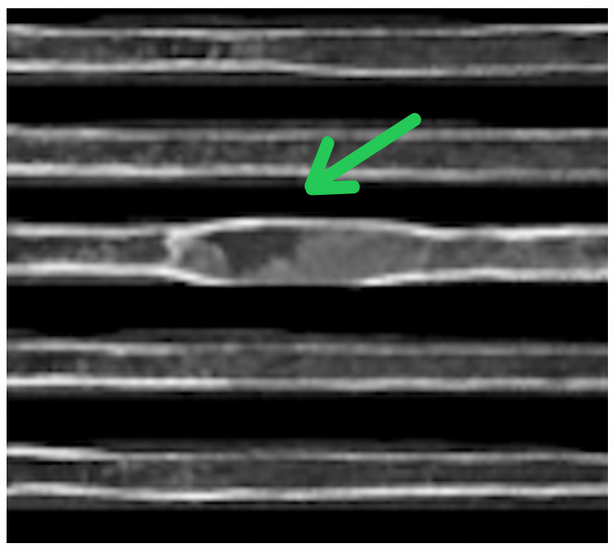
1 Enostosis / bone island

- Round or oval, well-defined, non-expansile, sclerotic focus within the trabecular bone.



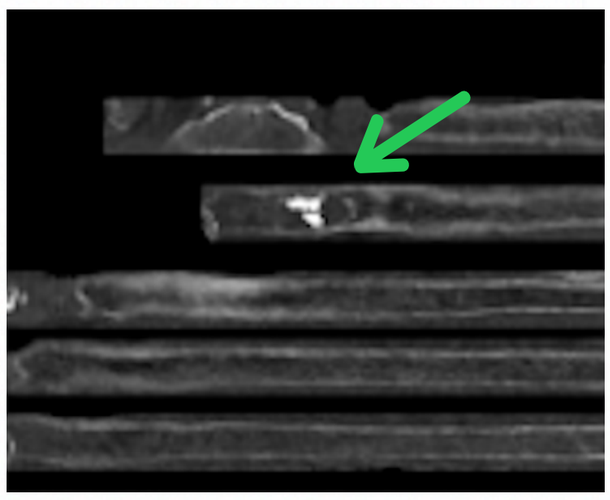
2 Fibrous dysplasia

- Homogeneous ground-glass matrix due to replacement of normal bone with fibrous tissue.
- Typically appears expansile, well demarcated, and may exhibit a characteristic “rind” sign of cortical thinning.



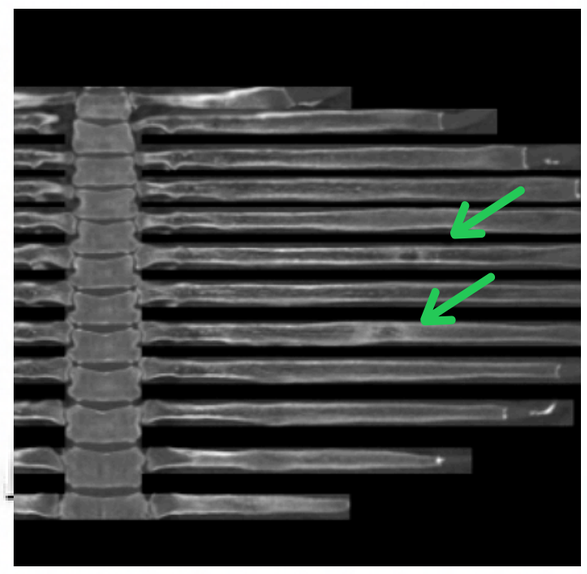
3 Enchondroma

- Benign cartilaginous tumour, appearing as a well-defined lucent or expansile lesion with internal chondroid mineralization.
- Frequently contains ring-and-arc or popcorn calcification.



4 Osteomyelitis

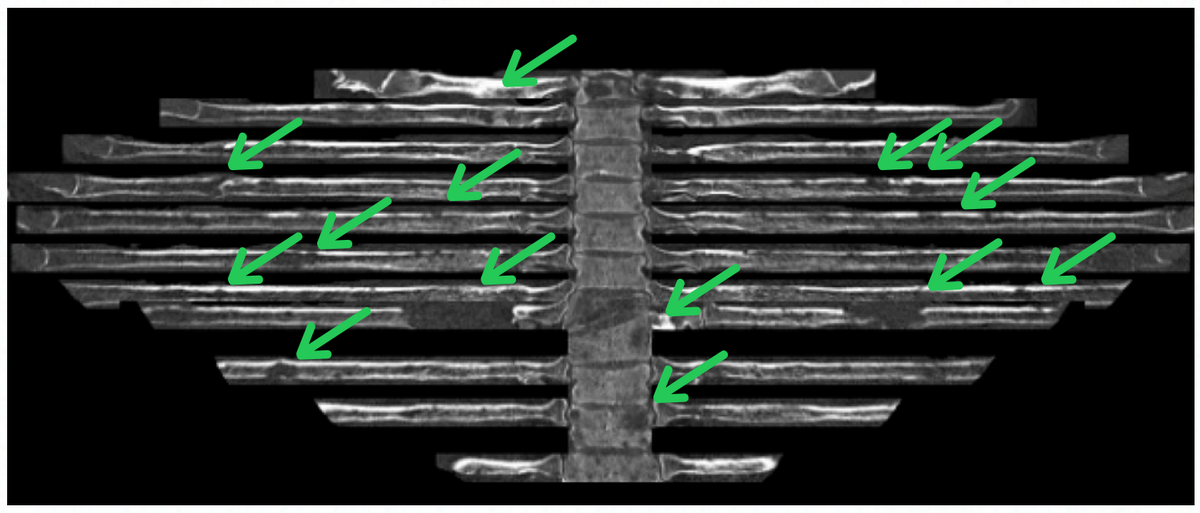
- Cortical irregularity or destruction, medullary lucency, periosteal reaction or sclerosis, with possible adjacent soft-tissue swelling, inflammatory stranding or abscess.
- Features may overlap with a fracture or neoplasm.



MALIGNANT LESIONS

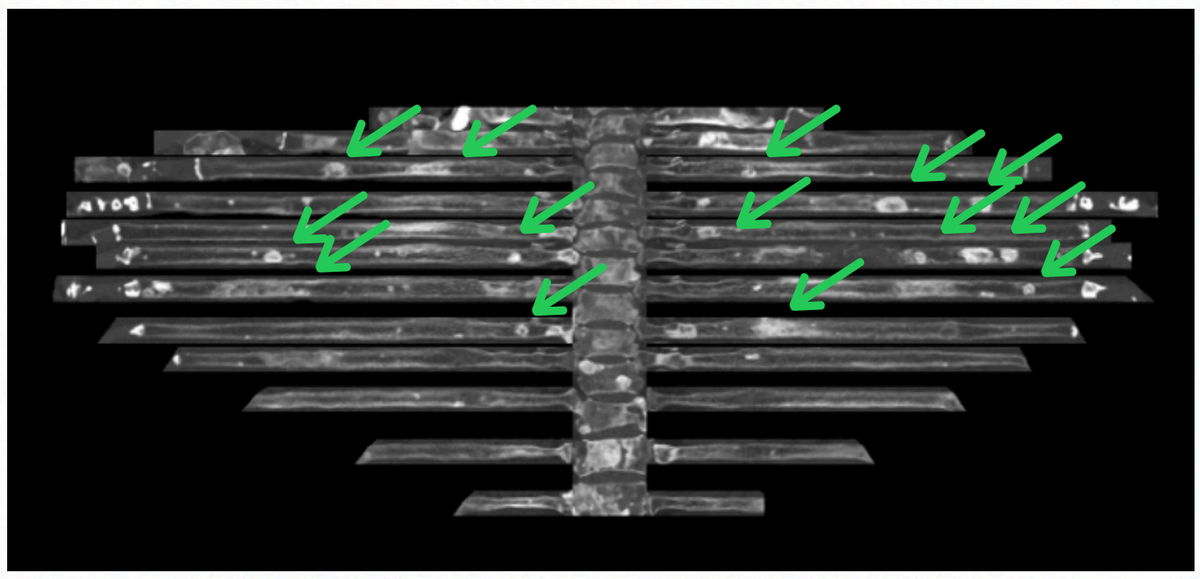
5 Multiple myeloma

- Multiple, well-defined, lytic lesions with a punched-out appearance. They are generally non-sclerotic and can be expansile, often affecting multiple ribs.



6 Rib metastases

- Most common malignant rib lesion. Common primary neoplasms include breast, prostate gland, lung, and kidney.
- Potentially lytic, blastic, or mixed, depending on the primary neoplasm.
- Aggressive features include cortical destruction, permeative marrow involvement, pathological fracture, periosteal reaction, or extra-osseous soft-tissue mass.



⚠️ **PITFALLS: Lesions on URCT can show overlapping features, limiting specificity. URCT is therefore best regarded as a screening and localization tool, with any suspected abnormality confirmed on standard axial and multiplanar CT**

CLINICAL UTILITY, ADVANTAGES AND TECHNICAL PITFALLS

ADVANTAGES

ENHANCED EFFICIENCY

Because the entire rib cage is mapped onto one plane, it allows radiologists to analyse all ribs at-a-glance. [1]

REPORTED READING-TIME REDUCTION

Studies have reported reduced reading time compared to conventional views, regardless of the reader's experience. Approximately by 27–54% in some studies, depending on software, image quality, and reader experience. [2,3]

AUTOMATED RECOGNITION AND LABELLING OF LEFT AND RIGHT RIBS

Automatic recognition and labelling of left and right ribs, allowing standardized localization and reduces tedious manual rib counting. [4]

DISADVANTAGES AND PITSFALLS

SEGMENTATION ERRORS

- The quality of the unfolded image heavily depends on accurate rib segmentation and centreline calculation.
- Algorithm may omit a portion of rib, merge adjacent ribs, or inadvertently include nearby structures such as the scapula or vertebral bodies, potentially obscuring pathology or creating pseudolesions.
- Errors may increase with anatomical variants, such as hypoplastic or fused ribs, severe deformity or atypical vertebral/rib count. Although manual correction can tackle this, it offsets the time-saving benefit. [5]

GEOMETRIC DISTORTION

- Occurs when a curved 3D structure is flattened into 2D, altering the apparent length, shape, orientation, or location of the concerned lesion. [6]
- Oblique fractures may appear more transverse or less conspicuous, and small cortical defects or lytic lesions may be averaged or poorly aligned. Thus, suspected abnormalities should be assessed on standard axial and multiplanar views for optimal characterisation. [7]

LOSS OF 3D SPATIAL CONTEXT

- Limits assessment of depth, surface location and relationships to adjacent structure (e.g. pleura, lung, neurovascular bundle, vertebrae, scapula and chest wall soft tissues), especially at costovertebral and costochondral junctions.

TAKEAWAY: URCT is a valuable screening and localization tool that allows swift visualization of the entire rib cage, reduces reading time, and labels ribs automatically. Suspected abnormalities, however, require confirmation on standard axial and multiplanar CT.

CONCLUSION AND REFERENCES

CONCLUSION

- URCT is a valuable screening and localisation tool for rib abnormalities.
- Key advantages are rapid visualization of the entire rib cage, automated rib labelling and potential reduction in reading time.
- Limitations include segmentation errors, geometric distortion and loss of 3D spatial context.
- URCT should complement rather than replace conventional and multiplanar CT.
- Suspected abnormalities should be confirmed on standard axial and multiplanar images.

PRACTICAL POINTS

1. Check segmentation and rib numbering.
2. Correlate any suspected lesion or fracture with axial and multiplanar views.
3. Assess relation of lesion to adjacent structures conventionally.

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