Mapping Pulmonary Emboli with Varying Computed Tomography (CT) Applications

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Introduction

Computed tomography (CT) is a Medical Imaging modality involving one or two x-ray tubes that rotate around the anatomy of interest while creating cross-sectional images (Long, Rollins, & Smith, 2019, p. 206).

Computed Tomography Components

- Gantry: large, circular housing unit containing x-ray tube, digital acquisition system (DAS), detector array, & generator.
- Table: bed that holds the patient while moving in increments during the scan.
- Computer: provides connection between CT technologist & rest of the imaging system.
- Operator's console: separate computer & keyboard enabling CT technologist to control the scanner.
- Power injector: special assembly that injects iodinated contrast media at a flow rate set by the CT technologist.

(Long et al., 2019, p. 213)

Multiplanar Reformations (MPR)

Reorganizes image slices revealing a new volume of data displayed in different planes from original.

- Coronal: images are displayed anterior to posterior.
- Sagittal: images are displayed lateral to medial.

(Long et al., 2019, p. 217)

Iodinated Contrast Media

Thick solution injected intravenously to distinguish normal anatomy from pathology & increase density of blood vessels.

(Long et al., 2019, p. 220)

Pulmonary Embolism (PE)

Life-threatening disease involving blood-clot formation elsewhere in the body & travel to heart and lungs, possibly causing a blockage in the pulmonary arteries.

Symptoms: shortness of breath, chest pain, and cough.

Types of PEs: occlusive (completely blocking the lumen) & partial occlusive (not completely blocking the lumen).

Incidence of PEs: estimated to be 71-74.5 per 100,000 people in the United States & is increasing each year.

(Muñoz, Silencio, & Larico, 2021, pp. 22-24)

A 3-month all-cause mortality rate for PEs is 3.9%-15.3% (Weidman et al., 2018a, p. 1).

CT Scanning Applications

Multidetector computed tomography (MDCT): type of third-generation CT scanner involving an increased number of detector rows, allowing multiple image slices acquired per rotation (Long et al., 2019, p. 210).

Dual-energy computed tomography angiography (DECTA): application utilizing different energy levels of x-rays to distinguish materials, tissues, & pathologies while using contrast media, based on varying attenuation coefficients of the body (Muñoz et al., 2021, p. 22).

Subtraction CT: application that digitally subtracts precontrast scan from contrast-enhanced scan after motion correction (Grob et al., 2019a, p. 198).

Iodine map technology depicts abnormalities corresponding to loss of blood flow caused by PEs & improves the sensitivity of detection of pulmonary emboli (Grob et al., 2019a, p. 197).

Data

Comparing DECTA versus MDCTA

372 PEs found in 147 of 1144 exams acquired with MDCTA.

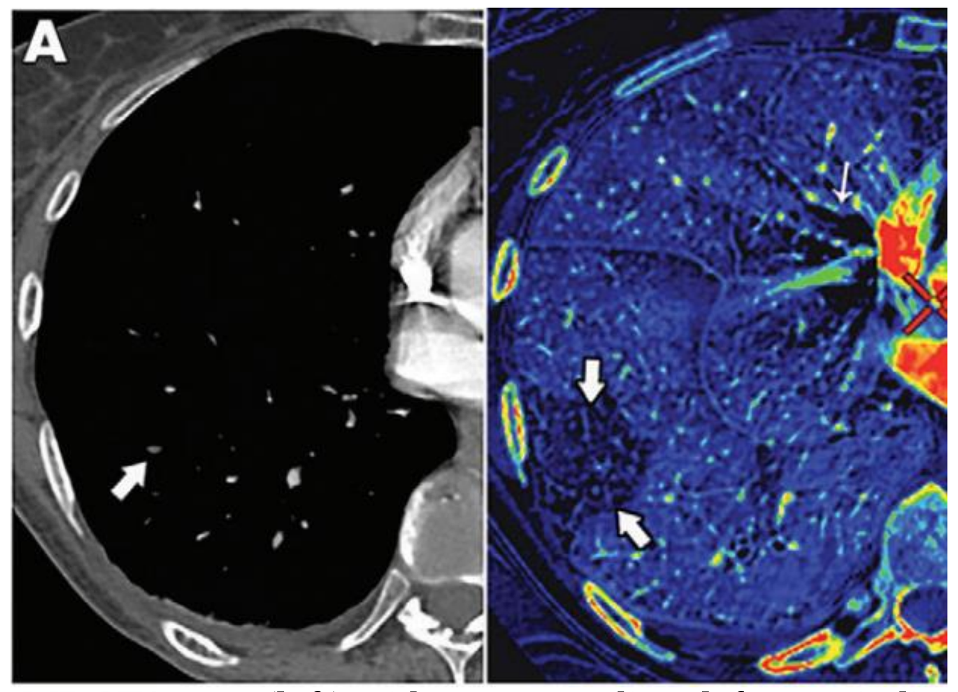
  - 20 in main pulmonary artery, 76 lobar level, 149 segmental level, 127 subsegmental level.

- 2238 defects in iodine maps found from the total 1144 exams.
  - 137 defects had corresponding PEs on iodine maps derived from MDCTA & DECTA scans.
- 27 new PEs detected in 26 of 1144 DECTA exams.

Comparing patient proportions:

- 127 patients had PEs detected on MDCTA exams versus 138 on DECTA exams out of 1035 total patients.

(Weidman et al., 2018a, pp. 549-551)



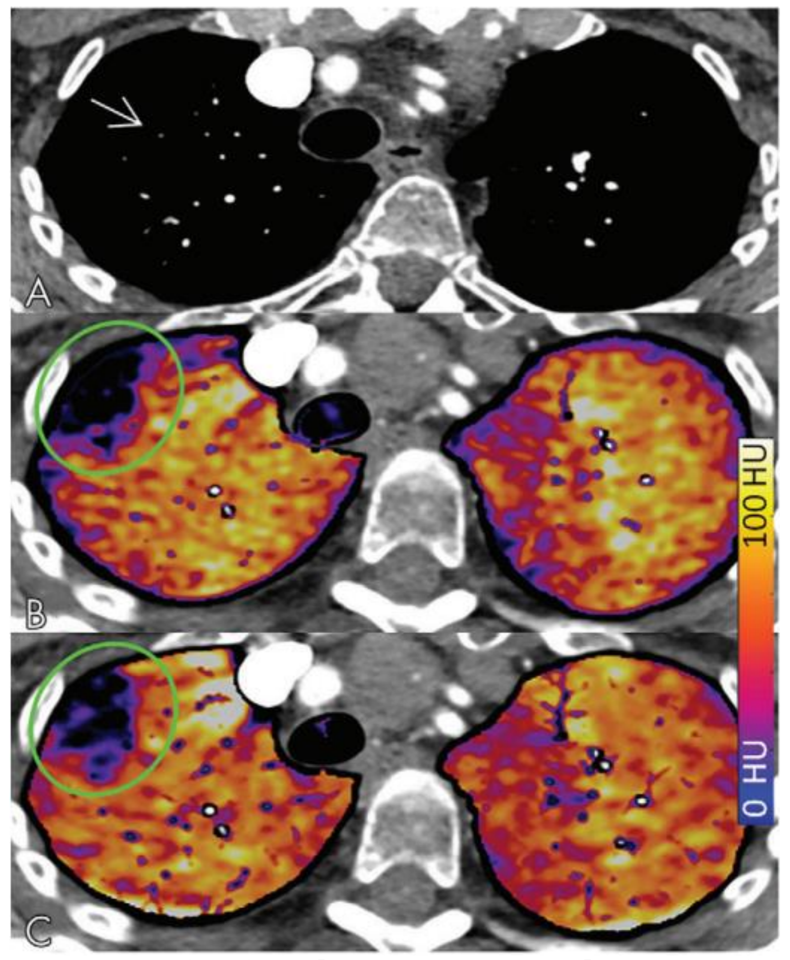
PE on MDCTA scan (left) with corresponding defect on iodine map (right) (Weidman et al., 2018b, p. 548).

Comparing Subtraction CT versus DECTA

DECTA iodine maps derived from DECTA images. Precontrast images subtracted from contrast-enhanced images of the original volume to create subtraction iodine maps.

- Out of 75 participants, 37 had confirmed PEs on DECTA exams.
- Small improvements were demonstrated in the specificity of iodine maps.
  - 100% for subtraction CT, 95% for DECTA, compared to 94% for MDCTA.

(Grob et al., 2019a, pp. 198-201)



PE on MDCTA scan (top), subtraction CT iodine map (middle), & DECTA iodine map (bottom) (Grob et al., 2019b, p. 203).

DECTA Iodine Maps

34 PEs detected in 24 DECTA exams.

- 3 in main pulmonary artery, 7 lobar level, 14 segmental level, 10 subsegmental level.

Of the 41 perfusion defects identified in 24 DECTA exams, 29 were consistent with PEs.

- 27 of the 29 had perfusion defects (20 occlusive, 7 partial occlusive), therefore, 2 additional PEs were identified (5.56%).

(Muñoz et al., 2021, pp. 25-27)

- DECTA iodine map specificity for occlusive PEs was 83% & 57% for non-occlusive (Tan, Lau, Borsaru, Jackson, & Nandurkar, 2019, p. 246).
- The specificity of central and segmental PEs was similar, measuring at 93% (Tan et al., 2019, p. 246).
- Mean sensitivity of iodine maps was 64% & mean specificity was 58% (Tan et al., 2019, p. 246).

Iodine Concentration Data

Quantitative measurements of iodine within normal parenchyma and parenchyma with perfusion defects demonstrated significant differences:

Normal parenchyma: minimum: 0.88 mg/ml, maximum: 2.79 mg/ml, average: 1.65 +/- 0.66 mg/ml.

Parenchyma with perfusion defects: minimum: 0.12 mg/ml, maximum: 1.02 mg/ml, average: 0.49 +/- 0.24 mg/ml.

Quantitative measurements varied by type of PE:

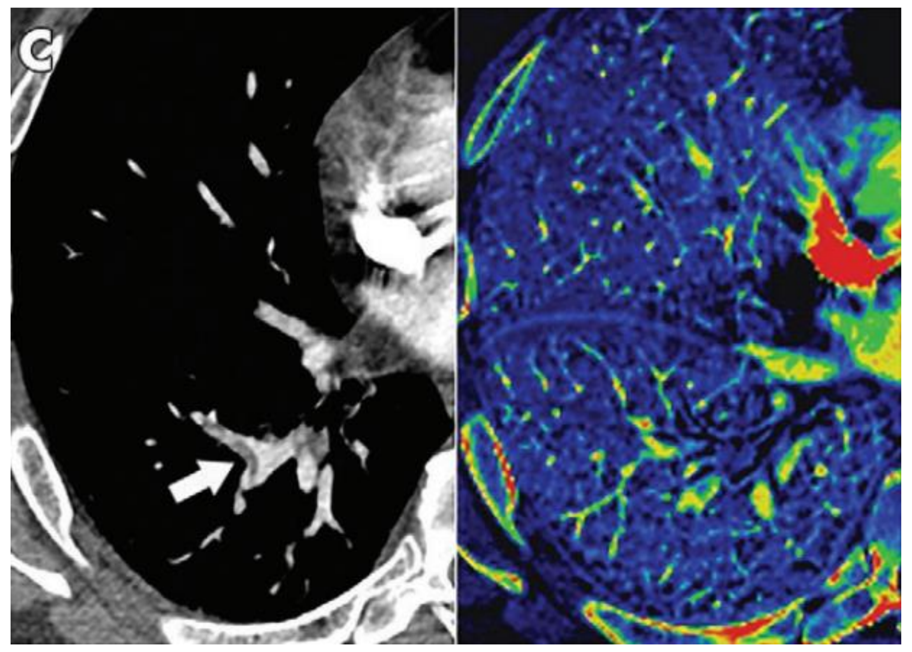
Total occlusive PE: minimum: 0.12 mg/ml, maximum: 0.66 mg/ml, average: 0.39 +/- 0.16 mg/ml.

Partial occlusive PE: minimum: 0.56 mg/ml, maximum: 1.02 mg/ml, average: 0.80 +/- 0.18 mg/ml.

(Muñoz et al., 2021, pp. 27-28)

Potential Problems with Iodine Mapping

- Risk for false positive PE diagnosis due to difficulty distinguishing artifact or pathology apart from a PE (Tan et al., 2019, p. 247).
- MDCTA, DECTA, & subtraction CT scans may not always match iodine maps (Weidman et al., 2018a, p. 548).



PE on DECTA scan (left) but no corresponding evidence on iodine map (right) (Weidman et al., 2018c, p. 548).

Conclusion

Iodine mapping:

- demonstrates a great advantage in detecting PEs, specifically, occlusive segmental and subsegmental in nature.
- helpful in detecting PEs due to size & peripheral location.
- It is important to note iodine concentration measurements demonstrate the seriousness of PEs and urgency for treatment. With the use of iodine mapping, the diagnosis of PEs may become more accurate, leading to a decrease in mortality rates.

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