These dual-energy iodine maps allow assessment of the concentration of iodine in the lung parenchyma at the time of scanning and can act as a surrogate of lung perfusion providing additional information regarding respiratory physiology not usually obtainable on conventional anatomical CTPA images. The generation of these iodine maps using dual energy relies on the difference in attenuation of enhanced lung parenchyma at the 2 energies used (Fig. 1).

As can be seen in Fig. 2, this results in much higher signal generation compared with dual energy. This allows radiation doses to be reduced to very low levels on both pre and post contrast scans whilst maintaining a high signal to noise ratio. In combination with the ultra-dose efficient PUREVISION detector this allows iodine maps to be used routinely in the investigation of thromboembolic disease at extremely low radiation doses. Although conceptually simple, the key to the success of SURESubtraction is advanced non-rigid registration allowing compensation for slight patient movement or differences in breathing between the pre and post contrast scans. SURESubtraction also has the advantage that there is no restriction on field of view, allowing iodine maps to be obtained even in large patients (dual tube systems are restricted due to the limited field of view of the ‘B’ tube).

SURESubtraction – IODINE MAPS WITHOUT THE RADIATION PENALTY
This is a novel technique whereby signal generated from a pre contrast image (typically at 100 kVp) is subtracted from the same anatomical area scanned post contrast.

SURESubtraction does not slow workflow
In order to perform a SURESubtraction scan, the radiographer simply selects the appropriate protocol which automatically covers the same anatomical area on the pre and post contrast scans and automatically sets an appropriate modulated radiation dose for each run based on desired image quality (more noise can be

Post contrast iodine maps were introduced as part of dual-energy imaging over 10 years ago but these have never become part of routine practice in most centres for the investigation of pulmonary thromboembolic disease.

Figure 1: Iodine map generation with dual energy

Figure 2: Iodine map generation with SURESubtraction

SURE

Subtraction

1) Royal Bournemouth Hospital, UK
tolerated on the pre contrast scan thus the radiation dose is set to be lower). On the newest version 7 software lung iodine maps are generated automatically in 3 planes and are sent to PACS together with the conventional anatomical CTPA images.

SURE SUBTRACTION ALLOWS MORE SENSITIVE DETECTION OF PULMONARY EMBOLI
The addition of functional images of lung iodine concentration to conventional post contrast anatomical images allows detection of sub-segmental emboli that would be otherwise missed.

SURE SUBTRACTION ALLOWS BETTER ASSESSMENT OF CHRONIC THROMBOEMBOLIC DISEASE
Anatomical images are able to assess resolution of central thrombus within the larger pulmonary vessels but are unable to accurately assess clot burden at the level of the small vessels which can be highly significant functionally (Figs. 4a, b, c).

SURE SUBTRACTION ALLOWS DETECTION OF SUBTLE LUNG DISEASE
Conditions such as small airways disease cause air trapping and reduced lung attenuation. Although this can be very significant functionally, this is easy to miss on conventional anatomical images as the difference in lung attenuation can be small (Fig. 5a). As air trapping leads to hypoxic pulmonary vasoconstriction, changes in blood flow and thus iodine concentration are much more obvious (Fig. 5b).

SURE SUBTRACTION INCREASES ROBUSTNESS
Despite apparent optimal timing, conventional CTPA studies are commonly not diagnostic due to inadequate vessel opacification. This is particularly common in
patients with high cardiac outputs due to e.g. sepsis or pregnancy due to contrast dilution and very rapid transit of contrast through the central pulmonary arteries leading to ‘late’ scan triggering. The addition of iodine maps allows an assessment of lung perfusion to be made even in the cases of poor central vascular opacification. In the setting of suboptimal pulmonary atrial opacification with normal lung iodine maps, pulmonary embolus can be excluded at low radiation dose (Fig. 6a, b).

CONCLUSION
For many years lung iodine perfusion maps generated using dual energy have been a promising technique but have had limited acceptance in routine practice due to the potential radiation penalty and/or need for specialized equipment. Lung SURESubtraction allows generation of these iodine maps at very low radiation doses using standard pre and post contrast images allowing the potential for this technique to be adopted in routine clinical practice.

Reference