Experiences of using a single post-contrast CT scan of the chest after biphasic contrast injection

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Introduction
While experimenting with single post-contrast computed tomographic (CT) scans of the urinary tract after a triphasic contrast injection,1 I considered whether a similar technique could be used to cut down on unnecessary scan series in our patients referred for chest CT scans. A precontrast scan and then a biphasic contrast injection followed by a single scan of the thorax was therefore considered and implemented to test the reliability and quality of this technique.

Protocols for chest CT surveys for mediastinal pathology, lung masses and ‘rule out pathology’ chest scans traditionally dictate a post-contrast scan beginning 60 s after initiating an intravenous contrast injection. In numerous practices, 100 - 120 cc of contrast is traditionally used. This process usually results in adequate contrast throughout the vascular structures in the mediastinum and lungs and enhancement of pathologic masses or lymph nodes.

When there are clinical indications of vascular pathology (i.e. aortic or pulmonary arteries and their respective branch vessels), it is imperative to add a dedicated arterial phase scan before the 60 s scan series. If there are no clinical indications to include an arterial phase, a single 60 s post-contrast scan only should be performed.

Unfortunately, clinical information from referring physicians is not always clear and, even when clear, many radiologists feel insecure without including an arterial series. We felt that this biphasic injection followed by a single post-contrast scan technique improved the diagnostic information and also alleviated the insecurity of excluding the arterial series when performing chest CT scans for non-vascular indications.

After scanning a few test cases using a single post-contrast series after a biphasic contrast injection, we were pleasantly surprised with the results, and we have now introduced this technique in most of our practice, when a ‘general rule out’ or ‘mass lesion characterisation’ scan is requested. This requires radiologists to shift their comfort zones, to rely on a single post-contrast scan replacing either a post-contrast arterial, 60 s, or both arterial and 60 s scans.

I have included a pictorial representation of a variety of pathologies while using the newer technique, to share our experiences over a wide range of pathologies, which will assist our colleagues in making this shift of technique with more confidence, and will hopefully address some of the queries that may be raised.

Injection plan
1. 80 cc contrast @ 3 cc/s (27 s) – contributes to ‘venous phase’ of the scan
2. 20 cc saline @ 3 cc/s (7 s) – pushes contrast into system.
3. Delay (11 s)
4. 40 cc contrast @ 2.5 cc/s (16 s) – contributes to the ‘arterial phase’ of the scan
5. Followed by 20 cc saline @ 2.5 cc/s
6. The scan is started at 60 s, which is 15 s into the arterial phase of the injection, 1 s before the end of the injection. Most scanners require a 4 - 5 s delay from the time the scan is initiated until the first ‘cuts’ are taken – see comments in the discussion below.

Computed tomographic (CT) chest investigations can be enhanced; in many cases, the arterial phase of a post-contrast arterial and delay (60 seconds) study can be omitted when planning the contrast injection and scanning technique carefully. A biphasic contrast injection was used before starting a single 60-second post-contrast scan.

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Fig. 1. Injection plan.
Case studies
Normal arterial phase scan (Fig. 2)

Arterial phase-contrast scans of the chest show good contrast enhancement of pulmonary arteries and veins, heart chambers, the aorta and its branch vessels. There is good differentiation of contrast between the central venous and arterial structures (dense enhancement v. no enhancement). The returning systemic veins contralateral to the side injected, from the head and neck, from infradiaphragmatic veins (especially the azygos vein) and any mediastinal and hilar masses and lymph nodes and lung pathology are not enhanced at this early post-contrast phase. Consequently, there is often difficulty in differentiating the unenhanced dilated or anomalous venous structures from the unenhanced lymph nodes and masses in the chest.

Normal 60 s post-contrast scan (Fig. 3)
The contrast enhancement of the vascular structures, mass lesions and lymph nodes within the chest is usually adequate, but differentiation between central arterial and venous structures and returning systemic venous structures relies on anatomical identification, as the contrast density of these structures is usually very similar. The contrast in the pulmonary arteries and branches is often mediocre, and incidental pulmonary arterial emboli may not be well seen.

Post biphasic contrast injection scan (Fig. 4)
After a biphasic contrast injection, there is dense enhancement of central pulmonary arteries and veins and the aorta and its branches. Returning systemic veins also show enhancement, but less dense than the central vessels, allowing further clarity to confirm the anatomical differentiation. Lung and mediastinal masses and lymph nodes will also enhance, usually to a lesser degree than systemic veins, and will show their enhancement patterns.

Lung carcinoma after biphasic contrast injection (Fig. 5)
Despite the scan beginning at 60 s, there is dense enhancement of the pulmonary arteries, veins and aorta, without compromising enhancement and characterisation of the lung mass and lymph nodes.

Mycetoma after biphasic contrast injection (Fig. 6)
It is interesting to compare this case with the preceding lung carcinoma case (Fig. 5), where there was enhancement of the mass and the typical peripheral enhancement of infiltrated lymph nodes, unlike the non-enhancement of this mass and the uniform node enhancement.

Lymphoma after biphasic contrast injection (Fig. 7)
Having dense contrast in all the vascular structures, with enhancement of the mass, all on one post-contrast series, helped to ‘unpack’ all the pathological processes going on in this case, which initially appeared quite complex because of the gross changes.
**PICTORIAL INTERLUDE**

**Goitre after biphasic contrast injection (Fig. 8)**

Although not a particularly challenging diagnosis to make, following the enhanced thyroid from the neck, into the mediastinum, and differentiation from adjacent vascular structures all on one post-contrast series was made easier in this case.

**Sarcoid after biphasic contrast injection (Fig. 9)**

There is clear differentiation of the enhancing lymph nodes from the adjacent, more densely enhancing vascular structures. Again, this is not a particularly challenging call to make – but compare with the next case below (Fig. 10).

**Interstitial lung disease after biphasic contrast injection (Fig. 10)**

The lymphadenopathy was more subtle than the sarcoid case above, but can be confidently called because of the adjacent azygos vein and aortic enhancement.
Opportunistic infection after biphasic contrast injection (Fig. 11)
The pulmonary arterial emboli might not have been as clearly seen on a single standard post-contrast 60 s scan, and the splenic micro-abscesses might also have been missed on a standard post-arterial scan. These were all seen on the single post-contrast series.

Atelectasis after biphasic contrast injection (Fig. 12)
The collapsed lung is enhanced, with dense enhancement of vascular structures.

Discussion
The contrast load traditionally used for a survey chest CT is 100 - 120 cc, to gain adequate contrast density in vascular structures in the chest. A rule
The initial 80 cc starting 60 s before the scan allows adequate contrast reduction in radiation to the patient from unnecessary extra scan series. The 60 s initiation of the scan after the beginning of the contrast enhancement of masses and lymph nodes allowed their differentiation between systemic returning veins and mediastinal and hilar masses and lymph nodes.

A second contrast injection begins 15 s before the CT scan starts. This adequate enhancement of returning systemic veins, to help differentiate them from mediastinal and hilar masses and lymph nodes.

A final saline chaser injection pushes the contrast towards the chest. This relatively dense contrast enhancement of pulmonary arteries, veins and thoracic aorta and its branches, which allowed clear differentiation between systemic returning veins and mediastinal and hilar masses and lymph nodes.

In patients with known poor cardiac function, the contrast passage may be a bit slower. In these cases, one may start the scan a little later – possibly at 65 s. This is still usually adequate as the contrast bolus tends to ‘stretch out’ i.e. a tight bolus injected into a peripheral vein over 15 s. will have spread out to possibly over 20 s by the time it has gone through the heart, lungs and heart again, before entering the aorta. In my opinion, the information gained is increased when compared with a single 60 s post-contrast scan.

Radiation exposure is reduced by omitting the arterial phase scan in practices where both an arterial and 60 s post-contrast are run for those cases where the arterial series is not indicated, but is added for the radiologist’s comfort.

Other advantages from reducing unnecessary series of post-contrast CT scans have been discussed in a previous article using a single post-contrast CT scan of the urinary tract after triphasic contrast injection.1 These advantages include:

• more efficient reading of the scans owing to more information presented on a single post-contrast series
• ease of viewing of a single scan post-contrast series for the referring clinician
• reduction in radiation to the patient from unnecessary extra scan series
• reduced wear and tear on scanner hardware
• reduction in the number of images needing electronic archiving.

It must again be emphasised that this technique is used to replace chest CT scans where the clinical information dictates a pre-contrast and a single post-contrast scan at 60 s and should not to be used when a dedicated arterial series is indicated.