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*Original Article*

# APPLICATION OF SPECTRAL CT IN DIFFERENTIATING INTRACRANIAL HEMORRHAGE FROM CONTRAST EXTRAVASATION AFTER MECHANICAL THROMBECTOMY AT THONG NHAT HOSPITAL: A PICTORIAL ESSAY

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**ABSTRACT**: After mechanical thrombectomy, hyperattenuating areas on non-contrast CT may represent intracranial hemorrhage, contrast extravasation, or both, and conventional CT may not reliably distinguish between them. This article aims to describe the role of spectral/dual-energy CT in this setting at Thong Nhat Hospital. It describes the principles and applications of virtual monoenergetic images (MonoE), virtual non-contrast (VNC) images, and iodine density maps generated on a Spectral CT 7500 system, illustrated by post-thrombectomy clinical cases from Thong Nhat Hospital. Iodine-containing lesions change more across MonoE energy levels, decrease or disappear on VNC images, and are visible on iodine density maps. Blood components tend to persist on VNC images and show less energy-dependent attenuation change; mixed lesions require integrated assessment of multiple spectral reconstructions. Spectral CT improves early differentiation between intracranial hemorrhage and contrast extravasation, supporting post-procedural antithrombotic decisions and follow-up. Findings should be interpreted together with the clinical context and follow-up imaging rather than against a single universal iodine concentration threshold.

**Keywords**: spectral CT; dual-energy CT; mechanical thrombectomy; intracranial hemorrhage; contrast extravasation; iodine density map

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# 1. INTRODUCTION

Mechanical thrombectomy is a highly effective treatment for patients with stroke caused by cerebral artery occlusion who arrive at the hospital within the treatment window[1,2]. This window has now been extended to 24 hours[3]. However, intracranial hemorrhage is one of the most important post-procedural complications affecting patient mortality. Accurate assessment of this complication is therefore necessary to select the treatment strategy and to manage and monitor patients after the procedure, maximizing the benefit of mechanical thrombectomy and reducing mortality. A common difficulty in practice is the appearance of hyperdense areas on conventional brain CT. These hyperdense areas do not always represent hemorrhage. Substantial amounts of iodinated contrast medium are used during angiography and thrombectomy. When the blood–brain barrier is damaged by cerebral ischemia, reperfusion, or the mechanical effects of the procedure, contrast medium can leak out of the vessels and accumulate in the brain parenchyma or the subarachnoid space. When only conventional CT is available, these cases have to be followed up with repeat non-contrast brain CT, because contrast extravasation usually persists for only about 48-72 hours after the procedure[4,5]. Dual-energy computed tomography (DECT) is an imaging technique that can help distinguish true cerebral hemorrhage from post-procedural contrast extravasation caused by blood–brain barrier injury[6,7]

The Spectral CT 7500 system at Thong Nhat Hospital uses dual-layer detector technology, which acquires spectral data simultaneously in a single scan without additional acquisitions. As a result, the system provides high-quality conventional CT images and also allows material composition analysis, with iodine quantification and differentiation of different materials. This extends its diagnostic value, especially in assessing vascular lesions and oncological diseases and in situations where contrast medium must be distinguished from hemorrhage. In addition, acquiring spectral data in the same scan reduces the need for repeat scans, which helps optimize the workflow and lower the radiation dose to patients.

This article presents the value of MonoE (monochromatic energy), VNC (virtual non-contrast), and iodine density reconstructions on spectral CT in the evaluation after cerebral endovascular intervention, together with several clinical cases from our hospital. All of these cases were followed up and the diagnosis confirmed with repeat brain computed tomography or brain magnetic resonance imaging within 48-72 hours after the procedure

# 2. APPLICATIONS OF SPECTRAL CT IN THE EVALUATION OF PATIENTS AFTER MECHANICAL THROMBECTOMY

## 2.1. MonoE images

MonoE images are simulated monoenergetic images at a defined energy level. The change in attenuation with energy level, especially at low energies, mainly reflects the X-ray absorption properties of high-atomic-number materials; iodine shows a marked increase in absorption as photon energy decreases. Images reconstructed at low energy levels such as 40 keV therefore increase iodine contrast, making contrast-containing areas more conspicuous. As the energy level increases, the effect of iodine gradually decreases.

Therefore, the change in attenuation of a lesion across energy levels can provide additional information on the presence of iodine; in other words, it suggests an area containing contrast medium rather than true hemorrhage. In the cases recorded at Thong Nhat Hospital, areas of contrast extravasation showed a clear change in attenuation on MonoE images at 40, 70, and 200 keV. In contrast, true cerebral hemorrhage did not change in appearance across MonoE images at different energy levels

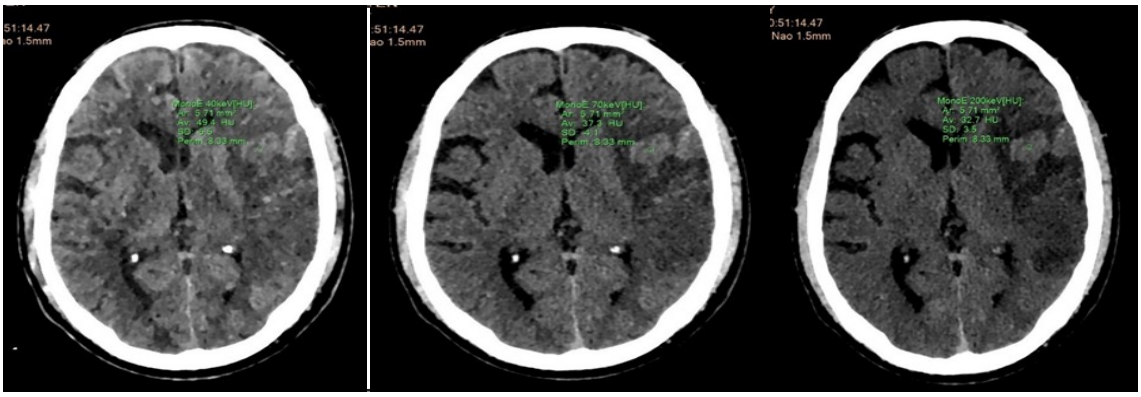


**Figure 1: Post-procedural parenchymal hemorrhage.** Spontaneous hyperdensity in the left frontal lobe, unchanged on MonoE images at 40, 70, and 200 keV. Source: Thong Nhat Hospital

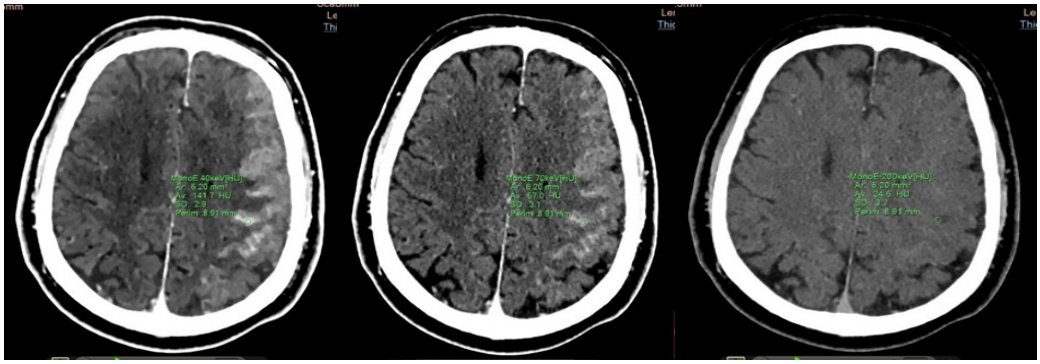


**Figure 2: Patient with post-procedural contrast extravasation; hyperdensity of the sulci in the left hemisphere, with attenuation changing across MonoE energy levels of 40, 70, and 200 keV.** Source: Thong Nhat Hospital

## 2.2. Virtual non-contrast images

VNC images are reconstructions in which the iodine component has been removed from the DECT images, producing images similar to non-contrast CT. This series is particularly useful in the post-procedural setting. If an area that is hyperdense on iodine-containing images remains hyperdense on VNC images, this supports the presence of a blood component. Conversely, if the hyperdense area decreases or disappears on VNC images, the cause may be mainly iodine.

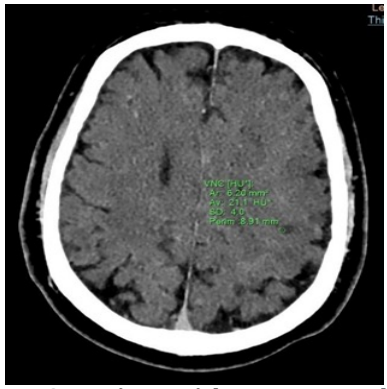


**Figure 3: Patient with post-procedural parenchymal hemorrhage, unchanged on VNC images.** Source: Thong Nhat Hospital

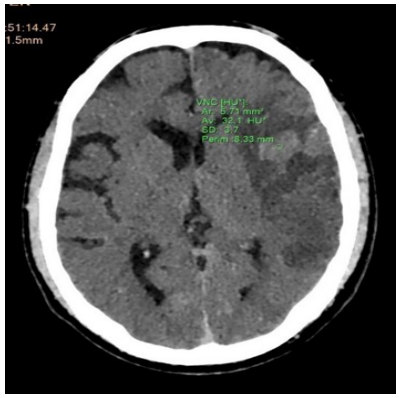


**Figure 4: Patient with post-procedural contrast extravasation; the spontaneous hyperdensity disappears on VNC images.** Source: Thong Nhat Hospital

## 2.3. Iodine density images

Iodine density is a map of iodine distribution and quantification in the examined region. It is one of the main advantages of DECT because it allows direct measurement of iodine concentration in the suspected lesion.

Recent studies on threshold values for detecting iodine in lesional tissue, particularly studies on Philips DECT systems (largely comparable to the Philips Spectral CT 7500 system used at Thong Nhat Hospital), used a cut-off of 0.5 mg/ml to detect iodine in the examined tissue.[8,9]

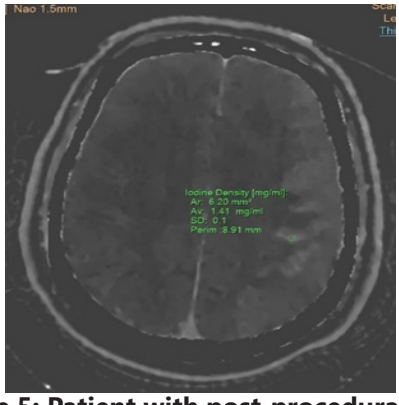


**Figure 5: Patient with post-procedural contrast extravasation; iodine concentration on the iodine density image is 1.41** mg/ml (>0.5 mg/ml). Source: Thong Nhat Hospital

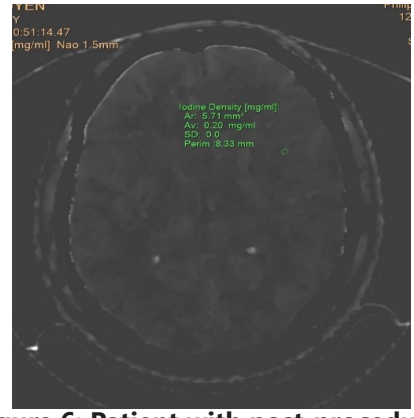


**Figure 6: Patient with post-procedural parenchymal hemorrhage; iodine concentration on the iodine density image is 0.**2 mg/ml (<0.5 mg/ml). Source: Thong Nhat Hospital

# 3. DISCUSSION

A hyperdense area after the procedure can be approached in the following steps:

Step 1 – Assessment on MonoE images: determine the location, morphology, and degree of hyperdensity; compare the change in attenuation between energy levels, especially between low and high energy levels.

Step 2 – Assessment on VNC images: if the hyperdense area persists on VNC images, a blood component is likely; if the hyperdense area decreases markedly or disappears on VNC images, an iodine component should be considered.

Step 3 – Assessment on iodine density images: measure the iodine concentration at the suspected site

This approach avoids relying on a single attenuation value (HU)

Table 1: Features suggesting intracranial hemorrhage versus contrast extravasation on DECT.

| Characteristic | Suggests intracranial hemorrhage | Suggests contrast extravasation |
|---|---|---|
| MonoE | Hyperdense | Hyperdense |
| Change with energy level | Usually little change | Marked change, especially at low energy |
| VNC | Hyperdensity persists | Hyperdensity decreases or disappears |
| Iodine density | Iodine concentration <0.5 mg/ml | Iodine concentration >0.5 mg/ml |
| Nature | Blood | Iodine |
| Significance | Hemorrhagic complication | Blood–brain barrier injury/ extravasation |

DECT should be performed as early as possible. In clinical practice at Thong Nhat Hospital, however, there is a delay before scanning, and the timing varies between patients. Studies worldwide only state that DECT was performed immediately after the procedure and do not report the exact interval from the end of the procedure to the follow-up scan[10,11]. Even so, scan timing is a factor that should be recorded and taken into account when interpreting DECT images.

Each image reconstruction technique has certain limitations when evaluated alone. On MonoE images, increased attenuation is not specific to iodine and should not be used as an independent criterion to distinguish hemorrhage from contrast extravasation. Blood can also show increased attenuation on MonoE images, and the degree of increase may vary with the energy level, material concentration, and other technical factors. Likewise, VNC images are generated by the material decomposition algorithm of the spectral CT system and may therefore be affected by image noise, material decomposition errors, beam hardening, and the presence of residual iodine. In particular, incomplete iodine removal can produce spurious hyperdensity on VNC images, whereas excessive iodine removal can reduce the attenuation of truly hyperdense components. These limitations may affect the detection of small-volume hemorrhages or lesions with high iodine concentration. Therefore, a decrease or loss of lesion hyperdensity on VNC images is not considered a criterion for excluding hemorrhage. For these reasons, spectral CT reconstructions should not be evaluated individually, nor can they be regarded as independent criteria for determining the nature of a lesion. Differentiation of hemorrhage from iodine should be based on a combination of all images, the clinical course, and findings on subsequent follow-up imaging

In addition, hemorrhage and contrast extravasation may coexist in some cases; multiple image series must then be analyzed together to reach an accurate conclusion. Several studies worldwide have shown that DECT can distinguish hemorrhage from contrast extravasation with a very high sensitivity of up to 100%[7,12]

Although the number of cases is still limited, the initial use of DECT to evaluate patients after mechanical thrombectomy at Thong Nhat Hospital has shown promising results in terms of accuracy and the future potential of this technique. Studies with larger sample sizes are needed to determine its diagnostic value

## 4. CONCLUSION

Dual-energy CT (DECT) after mechanical thrombectomy, with MonoE, VNC, and iodine density reconstructions, is of high value in distinguishing cerebral hemorrhage from contrast extravasation after mechanical thrombectomy. In clinical practice, DECT can become an effective supporting tool; however, spectral imaging results still need to be interpreted and assessed together with the clinical findings and conventional CT images to improve diagnostic accuracy and to support follow-up, prognosis, and patient management.

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