

Diagnostic agreement of the baseline CT and dual-energy CT to differentiate the cerebral hemorrhage from contrast extravasation in patients with acute ischemic stroke after endovascular treatment.

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Purpose

The main complications of treatment of ischemic stroke is hemorrhagic transformation; large series have demonstrated its presence between 10-15% of strokes treated endovascularly, this results in a worse prognosis.

Sometimes, it is easy to recognize an intraparenchymal hematoma, but, considering the presence of contrast extravasation after intra-arterial recanalization occurs between 30-50% of cases, it can be a challenge differential diagnosis. In this situation Dual-energy CT takes an important role in patient management and prognosis.

Different studies have shown that the study with dual-energy CT is an excellent tool in differentiating between iodinated contrast and intracranial bleeding, finding high levels of sensitivity and specificity. However, to date has not been evaluated concordance of results between different observers according to their experience, as occur in clinical practice.

The purpose of this study was to determine the interobserver agreement of dual-energy CT and unenhanced CT between radiology resident and experimented neuroradiologists to detect and differentiate hemorrhage in patients with acute ischemic stroke after endovascular treatment.

Methods and Materials

We performed a retrospective analysis of prospective screened patients admitted to our center over a period of 3 years (2010-2012) showing an acute ischemic stroke treated endovascularly; according to our protocol, dual-energy CT was performed within the first 12 hours after endovascular treatment to rule out intracerebral bleeding in order to begin the antithrombotic treatment. We included all dual-energy CT with intracranial hyperdensities.

Thirty-nine patients were included (mean age 67, range 30 to 85 years), 16 men (mean age 66, range 49 to 83 years) and 23 women (mean age 67, range 30 to 85 years). No patients were lost during the study.

The image acquisition was obtained through a CT Somatom Definition (Siemens Healthcare, Forchheim, Germany), which uses two x-ray tubes (A and B) optimized independently (Kv, mA) and two detectors in the same gantry. Both tubes are fired simultaneously therefore the information from both tubes is acquired simultaneously reducing motion or image registration artifacts.

The protocol used was as follows: Tube A at 100 Kv and 250 mA, Tube B at 140 Kv and 250 mA, and a 20x0.6 mm collimation (total dose approximately 3 mSv effective, similar to a conventional head CT). The use of different energies is based on the attenuation behavior of a substance depends of the energy that is exposed (eg iodine attenuation is greater in 100 Kv than 140 Kv), enabling create set-images in which some materials are distinguished better than others.

The information obtained was rebuilt in the main console in three different series, two with a slice thickness of 1.5 mm, a set corresponding to 100 Kv ([Fig. 1](#) on page 6) and other to 140 Kv ([Fig. 2](#) on page 6); the third set was reconstructed with a slice thickness of 5.0 mm. This last set of images corresponded to both energy weighted (100 Kv/ 140 Kv) simulating a conventional CT of 120 Kv ([Fig. 3](#) on page 7). The series is stored in the PACS.

Was carried out post-processing images of 100 Hv and 140 Kv by means of a software (syngo Dual-Energy Brain Hemorrhage, Siemens) using a 3-material decomposition algorithm based on brain parenchyma, hemorrhage, and iodine. The program separates each voxel and compare the attenuation of two preset material (cerebral parenchymal and hemorrhage) in each set-images, 100 Kv and 140 Kv, thus the attenuating both substances must be linear in each series, when this linearity alters can be attributed to the presence of one third substance which is also preselected (iodine). This allows

obtaining an iodine map (for displaying this material, [Fig. 4](#) on page 8) and a virtual noncontrast map (to visualize brain parenchymal and hemorrhage, [Fig. 5](#) on page 9). The technique has a limitation; it can not distinguish more materials than 3, so the presence of calcium or metal materials can not be differentiated.

Extracted studies were randomized into 2 groups of reading (A and B), 21 and 18 patients each one. Group A was made up of a mixture map (weighted sum of the 100-kV and 140-kV images) simulating a conventional nonenhanced CT. Group B was made up of a dual-energy CT. Both groups were analyzed by three blinded observers to the clinical characteristics of each patient, 2 neuroradiologists with over 10 years of experience (NR1 and NR2) and a second-year resident (R2).

The image findings were classified as contrast extravasation (I) or hemorrhage according to ECASS radiological scale of cerebral bleeding (European Cooperative Acute Stroke Study, [Table 1](#) on page 10).

The results were dichotomized: Value 0 if correspond to contrast extravasation or haemorrhagic stroke ($I/IH1/IH2 = 0$), Value 1 if correspond to a parenchymal hematoma or remote hematoma ($PH1/PH2/RH = 1$); according with our protocol, the patients with value 0 ($I/IH1/IH2$) were treated in the first 24 hours with intravenous heparine. Therefore, patients with value 1 ($PH1/PH2/RH$) were contraindicated to antiacoagulation therapy. So, this was a dichotomization according to a treatment decision.

Finally, we analyzed the correlation of the readings between the 3 observers through the Kappa index value (k , [Table 2](#) on page 11) classifying the poor to excellent correlation using SPSS for statistical analysis.

Images for this section:

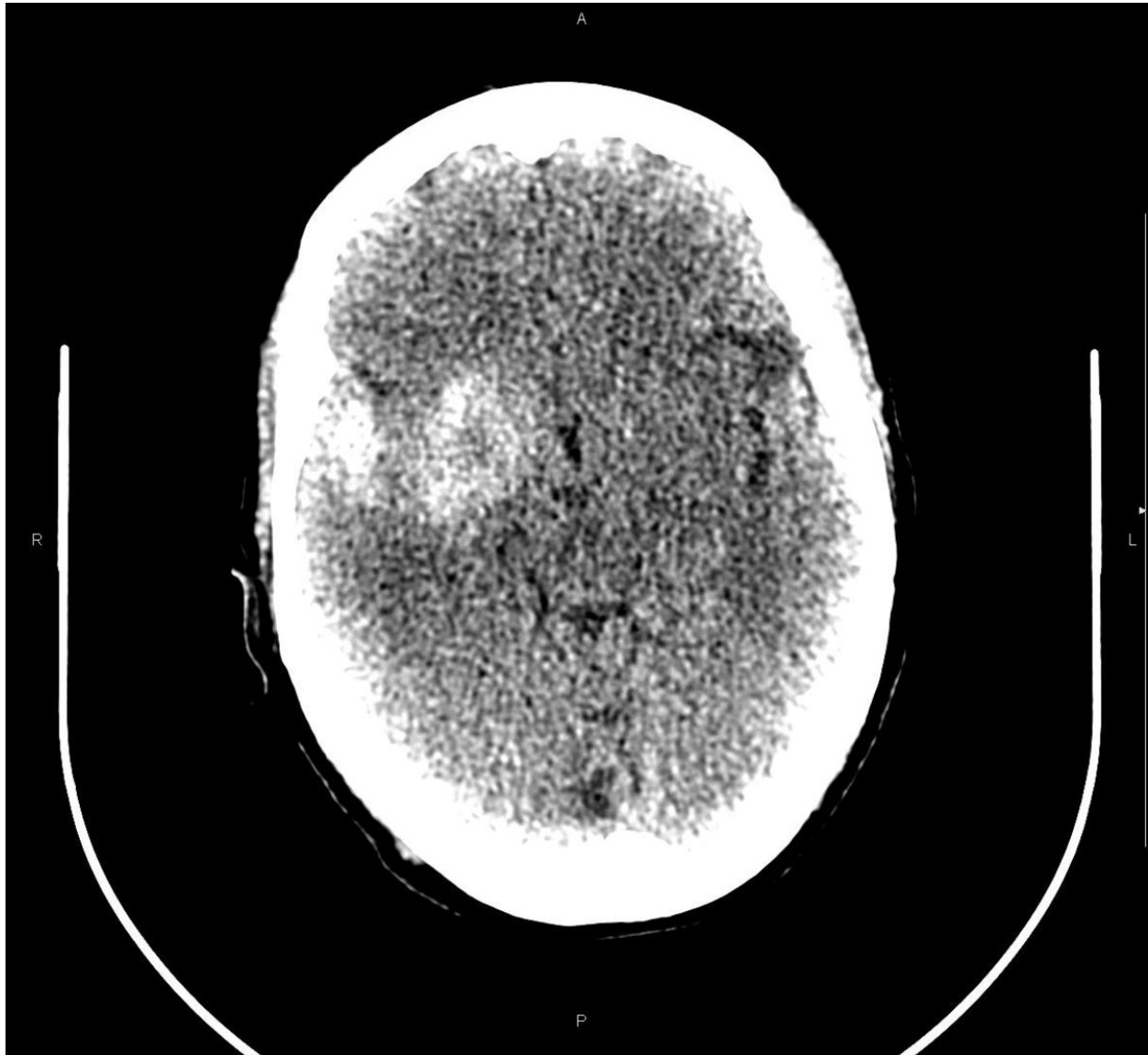


Fig. 1: Image at 100 Kv

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Fig. 2: Image at 140 Kv

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Fig. 3: Mixture map simulating a conventional CT of 120 Kv

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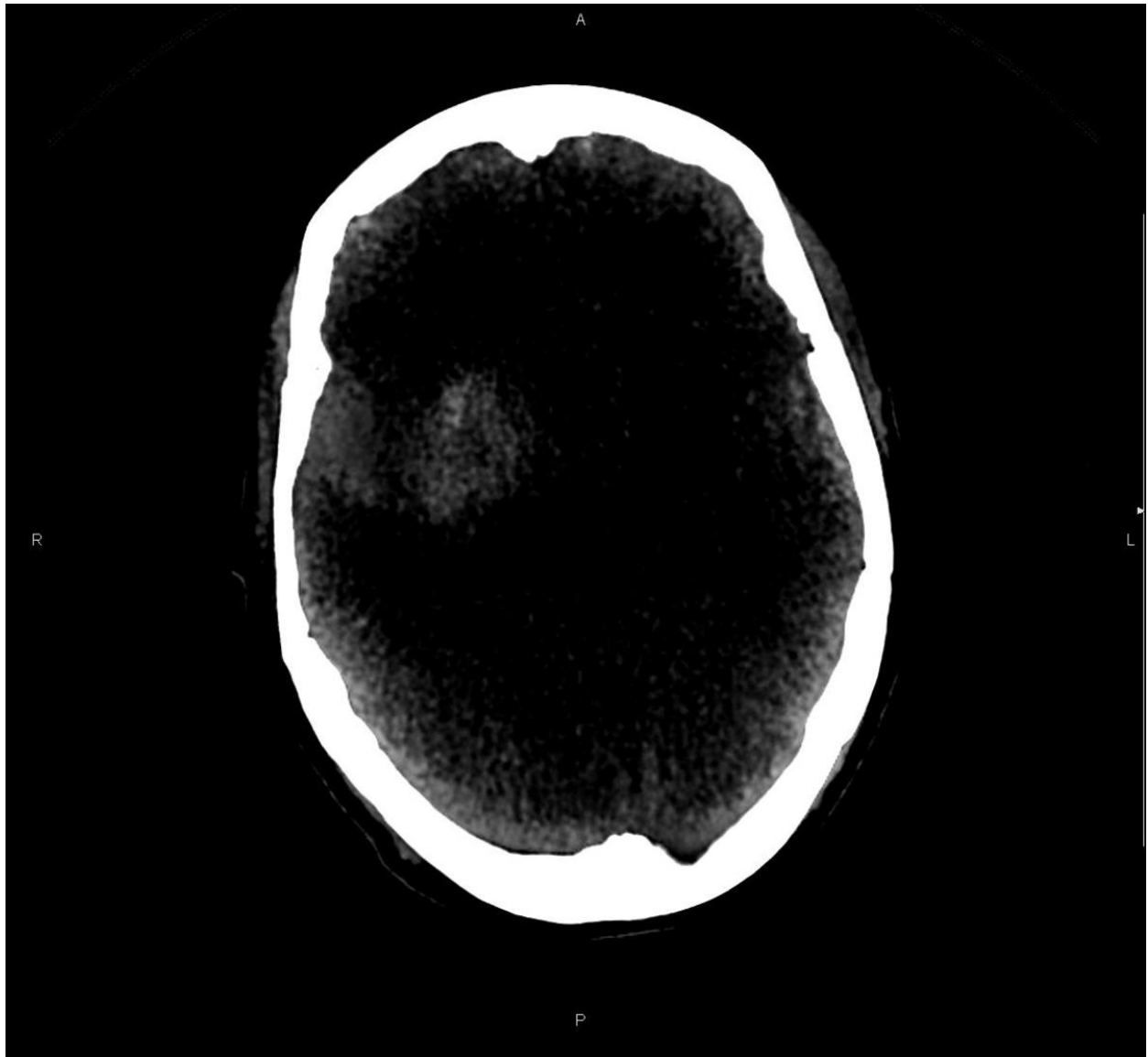


Fig. 4: Iodine map

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Fig. 5: Virtual noncontrast map

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ECASS SCALE	
IH 1	Small petechiae on the margin of the infarct
IH 2	Confluent petechiae in the infarct area without mass effect
PH 1	Hematoma occupying <30% of the cerebral infarction area with mild mass effect
PH 2	Hematoma occupying > 30% of the cerebral infarction area with clear mass effect
RH	Hematoma outside the infarct area

Table 1: ECASS Scale

© ECASS

KAPPA INDEX	
< 0,20	Poor
0,21 - 0,40	Weak
0,41 - 0,60	Moderate
0,61 - 0,80	Good
0,81 - 1	Excellent

Table 2: Kappa Index

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Results

The dichotomization of each observer is presented in the [Table 3](#) on page 13 .

The interobserver agreement obtained was excellent between experienced neuroradiologists in both conventional CT and dual-energy CT ($k = 0,83$ and $k = 1$ respectively).

We obtain a poor correlation comparing the readings of conventional TC between the experienced neuroradiologists and the second-year resident; $k = 0,41$ (NR1 vs R2) and $k = 0,31$ (NR2 vs R2).

However, we found a good correlation comparing dual-energy CT readings between the experienced neuroradiologists and the second-year resident; $k = 0,68$ (NR1 vs R2) and $k = 0,68$ (NR2 vs R2).

The comparison between the kappa index is shown in the [Table 4](#) on page 13 .

The improvement of the R2 k-index is secondary to decrease in detection of false bleeding; in this situation, misclassified patients would not benefit from anticoagulant therapy. The two remaining cases misclassified in dual-energy CT were false bleeding too, so all the cases represents "false positive" of bleeding.

However, if the fault was on the contrary, the failure to detect a hemorrhage could expose a bleeding patient to anticoagulation therapy. The mistake and the risk would not be acceptable.

Images for this section:

DICHOTOMIZATION						
	Convencional CT (mixture map)			Dual CT		
	NR1	NR2	R2	NR1	NR2	R2
0*	17	18	11	16	16	14
1**	4	3	10	3	3	5

* I/IH1/IH2/RH, ** PH1/PH2

Table 3: Dichotomization

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INTEROBSERVER AGREEMENT			
	NR1	NR2	R2
NR1		0,83	0,41
NR2	1		0,31
R2	0,68	0,68	



Dual-energy CT
Conventional CT

Table 4: Interobserver Agreement

Conclusion

Inexperienced observers increase the agreement with experienced neuroradiologists with dual-energy CT comparing to nonenhanced CT in the detection of hemorrhage transformation in acute stroke patients after endovascular treatment.

Therefore, dual-energy CT helps to inexperienced observers to perform a right diagnosis which has an important relevance in the management and outcome of the patients.

References

1. Larrue V, von Kummer R, Müller A, et al. Risk factors for severe hemorrhagic transformation in ischemic stroke patients treated with recombinant tissue plasminogen activator. A secondary analysis of the European-Australasian Acute Stroke Study (ECASS II). *Stroke* 2001; 32: 438-41.
2. von Kummer R. Effect of training in reading CT scans on patient selection for ECASS II. *Neurology* 1998; 51: S50-S52.
3. del Zoppo GJ, Higashida R, Furlan AJ, et al. PROACT: a phase II randomized trial of recombinant pro-urokinase by direct arterial delivery in acute middle cerebral artery stroke. *Stroke*. 1998; 29: 4-11.
4. Furlan A, Higashida R, Wechsler L, et al. Intra-arterial prourokinase for acute ischemic stroke: the PROACT II study: a randomized controlled trial. *JAMA*. 1999; 282: 2003-11.
5. Nakano S, Iseda T, Kawano H, Yoneyama T, et al. Parenchymal hyperdensity on computed tomography after intra-arterial reperfusion therapy for acute middle cerebral artery occlusion: incidence and clinical significance. *Stroke*. 2001; 32: 2042-48.
6. Nakano S, Iseda T, Yoneyama T, et al. Early CT signs in patients with acute middle cerebral artery occlusion: incidence of contrast staining and haemorrhagic transformations after intra-arterial reperfusion therapy. *Clin Radiol* 2006; 61: 156-62.
7. Yoon W, Seo JJ, Kim JK, et al. Contrast enhancement and contrast extravasation on computed tomography after intra-arterial thrombolysis in patients with acute ischemic stroke. *Stroke* 2004; 35: 876-81.
8. Paciaroni M, Agnelli G, Corea F, et al. Early hemorrhagic transformation of brain infarction: rate, predictive factors, and influence on clinical outcome: results of a prospective multicenter study. *Stroke* 2008; 39 (8): 2249-56.
9. Lovelock CE, Rothwell PM, Anslow P, et al. Substantial observer variability in the differentiation between primary intracerebral hemorrhage and hemorrhagic transformation of infarction on CT brain imaging. *Stroke*, 2009; 40: 3763-67.
10. Choi PMC, Ly JV, Srikanth V, et al. Differentiating between hemorrhagic infarct and parenchymal intracerebral hemorrhage. *Radiology Research and Practice* 2012; 10: 1155-66.
11. Greer DM, Koroshetz WJ, Cullen S, et al. Magnetic resonance imaging improves detection of intracerebral hemorrhage over computed tomography after intra-arterial thrombolysis. *Stroke* 2004; 35: 491-95.
12. Johnson TR, Krauss B, Sedlmair M, et al. Material differentiation by dual energy CT: initial experience. *Eur Radiol* 2007; 17: 1510-17
13. Graser A, Johnson TR, Chandarana H, et al. Dual energy CT: preliminary observations and potential clinical applications in the abdomen. *Eur Radiol* 2009; 19: 13-23.

14. Gupta R, Phan CM, Leidecker C, et al. Evaluation of dual-energy CT for differentiating intracerebral hemorrhage from iodinated contrast material staining. *Radiology* 2010; 257: 205-11.
15. Ferda J, Novak M, Mirka H, et al. The assessment of intracranial bleeding with virtual unenhanced imaging by means of dual-energy CT angiography. *Eur Radiol* 2009; 19: 2518-22.
16. Phan CM, Yoo AJ, Hirsch JA, et al. Differentiation of Hemorrhage from Iodinated Contrast in Different Intracranial Compartments Using Dual-Energy Head CT. *Am J Neuroradiol* 2012; 33: 1088-94.
17. Petersilka M, Bruder H, Krauss B, et al. Technical principles of dual source CT. *Eur Radiol* 2008; 68: 362-68
18. Karçaalt#ncaba M, Akta# A. Dual-energy CT revisited with multidetector CT: review of principles and clinical applications. *Diagn Interv Radiol* 2011; 17: 181-94
19. Kim SJ, Lim HK, Lee HY, et al. Dual-energy CT in the evaluation of intracerebral hemorrhage of unknown origin: Differentiation between tumor bleeding and pure hemorrhage. *Am J Neuroradiol* 2012; 33: 865-72.