Original article

J. Neuroradiol., 2005, *32*, 333-336

ASSESSMENT OF ACUTE SPONTANEOUS INTRACEREBRAL HEMATOMA BY CT PERFUSION IMAGING

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SUMMARY

A single-section deconvolution-derived computerized tomographic perfusion imaging was performed in 45 patients (22 male and 23 female; mean age=69.89±10.07 years) with acute supratentorial spontaneous intracerebral hemorrhage. Mean rCBF and rCBV were lower in the hemorrhagic core than in the perihematomal low density area ($p<0.001$), and in the perihematomal low density area than in normal appearing brain parenchyma ($p<0.001$). Mean rMTT values were higher in perihematomal low density area than in normal appearing area ($p<0.01$) and in both hemorrhagic and perihematomal area than in controlateral ROI ($p<0.001$). There were no differences in rMTT mean values between hemorrhagic core and perihematomal area, as well as between normal appearing and controlateral areas. We found a concentric distribution of all CT perfusion parameters characterized by an improvement from the core to the periphery, with low perihematomal rCBF and rCBV values suggesting edema formation.

Key words: CT-perfusion, intracerebral hematoma.

RÉSUMÉ

Imagerie de perfusion d'hématome intracérébral spontané évaluée par tomodensitométrie hémodynamique

Une coupe unique de scanner de perfusion avec déconvolution était réalisée chez 45 patients (22 hommes et 23 femmes; âge moyenne = 69,89 ± 10,07 years) présentant un hématome intracérébral aiguë sustentoriel (HIAS). Le débit sanguin cérébral (DSC) et volume sanguin cérébral (VSC) moyens est plus bas au centre qu'en périphérie de la zone d'hypodensité qui est plus bas qu'en zone isodense (p < 0,001). Les valeurs de temps de transit moyen (TTM) étaient > zones périlésionnelle > zone isodense (p < 0,001). Il n'y a pas eu de différence en TTM entre le centre et la zone périhémorragique. Nous avons trouvé une distribution centrifuge caracterisée par une amélioration des paramètres de perfusion du centre à la périphérie avec les valeurs basses de DSC VSC suggerant une formation d'édeme.

Mots-clés : *scanner de perfusion, hématome intracérébral.*

INTRODUCTION

A better understanding of the pathophysiological mechanisms underlying secondary neuronal damage that can affect the perihematomal tissue early after spontaneous intracerebral hemorrhage (SICH) is crucial for the choice of appropriate strategies of therapy [19].

Several efforts have previously been made to verify whether in the region peripheral to hematoma there exists a zone of ischemic penumbra, defined as severely hypoperfused tissue at risk for infarction which is functionally compromised but structurally intact and, therefore, still viable and salvageable if blood flow is rapidly restored [6]. However, the presence of ischemic penumbra tissue surrounding the hematoma remains controversial in both animal [1, 18] and human studies [7, 12, 15, 20, 21, 27]. Among the different techniques currently available to investigate perfusion abnormalities, dynamic computed tomography (CT) perfusion scanning has recently proven to be a promising tool for the detection of cerebral blood flow (CBF) disorders related to penumbral tissue [4, 25]. In this setting, it has been proposed that ischemic but hypothetically salvageable brain tissue could be identified by CT perfusion parameters [8, 13]. Based on these considerations and in an attempt to provide further insight into the assessment and the distribution of lesional and perilesional perfusion alterations, we sought to quantify CBF changes within and around acute SICH by using deconvolution-derived CT perfusion hemodynamic imaging.

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MATERIALS AND METHODS

Patients

We recruited in the study 45 patients with acute supratentorial SICH on unenhanced admission CT scans carried out within 24 hours of symptomatic onset. Time of onset was considered as the last time the patient was known to be neurologically normal. Patients with infratentorial hemorrhage, hematoma related to tumor, trauma, coagulopathy, aneurysms, vascular malformations, hemorrhagic transformation of brain infarction, intraventricular extension of hemorrhage and patients who had undergone surgical hematoma evacuation were excluded. Disease severity was scored in all patients at entry using Glasgow Coma Scale (GCS) [22]. Hematoma location was classified as basal ganglia or lobar. Hematoma volume was calculated using the formula A×B×C/2 [9]. Informed consent was obtained from each patient or from close relatives before the perfusion CT was performed.

CT perfusion studies

CT perfusion examinations were performed by using a single-section CT scanner (CT HiSpeed ZX/i; GE Healthcare, Milwaukee, Wis) equipped for CT perfusion imaging (CT Perfusion; GE Healthcare, Milwaukee, Wis). After hematoma localization on unenhanced CT scanning, the imaging protocol for CT perfusion consisted of a series of 45 CT scans acquired in a single slice (10-mm slice thickness, 80kVp; 200mAs; matrix 512×512; FOV 25-cm; total scan time 50sec) located at the hematoma level during the automatic injection of 50ml of non-ionic contrast agent at the rate of 3.5ml/sec, starting 5 seconds before the initial image. The reference image on non-contrast CT scans was selected on the basis of the level containing the largest volume of blood. All CT perfusion scans were assessed with a deconvolution-based algorithm by using an imaging workstation (Advantage Windows; GE Medical System, Milwaukee, Wis) supplied with a commercial dedicated software (CT Perfusion 2, GE Healthcare, Milwaukee, Wis). CBF, CBV and MTT perfusion maps were generated for each patient. As illustrated in *figure 1*, regional CBF (rCBF), CBV (rCBV) and MTT (rMTT) levels were measured in three different regions of interest (ROIs) larger than $1cm^2$ and manually outlined on the baseline single slice CT scan and including: 1) hemorrhagic core; 2) perihematomal low density area; 3) 1cm rim of normal appearing brain tissue surrounding the perilesional low density area. An additional ROI that mirrored the region including the clot and perihematomal low density area was placed in the contralateral hemisphere. CBF, CBV and MTT values were expressed in ml/100g/min, ml/100g and seconds, respectively. rCBF values lower than 10 ml/100g/min, ranging from 10 to 20ml/100g/min, and included between 20 and 40ml/100g/min were considered as ischemic, penumbral and oligemic, respectively [5]. In addition, rCBF levels greater than 55ml/100g/min were regarded as hyperperfusional [17]. rCBV levels lower than 1.5ml/100g, and rMTT levels higher than 6 seconds were considered as abnormal [4].

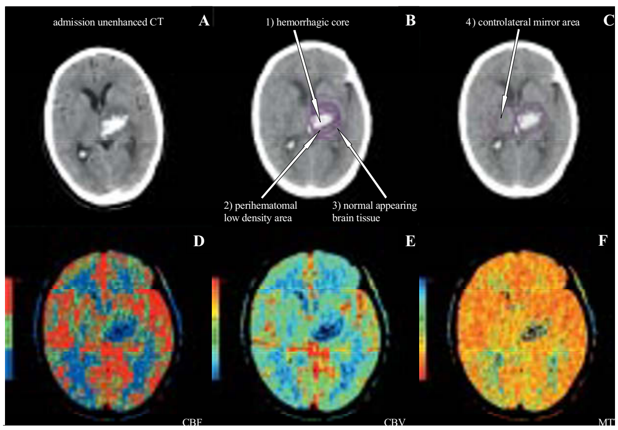

FIG. 1. – CT perfusion image of spontaneous intracerebral hemorrhage located in the left thalamus. *Image A* shows hematoma location on admission unehnanced CT scan. *Image B and C* show regions of interest placed within and around the hematoma and in the contralateral hemisphere on the baseline single slice CT scan. *Image D, E and F* depict maps of cerebral blood flow, cerebral blood volume and mean transit time.

FIG. 1. – *Image de perfusion CT d'un hématome intracérébral spontané au niveau du thalamus gauche. L'Image A montre la localisation de l'hématome au scanner sans injection à son admission. Les images B et C montrent les régions d'intérêt placée dans l'hématome, à sa périphérie et en contrelatéral sur une coupe de scanner de base. Les images D, E, F illustrent la cartographie du débit sanguin cérébral, du volume sanguin cérébral et le temps de transit moyen.*

Data analysis

Mann-Whitney U test was used to compare mean values among the various groups. The Spearman rank correlation coefficient test was used to identify possible relationships among the different variables. Statistical significance was set at $p<0.05$.

RESULTS

Patients characteristics

Demographic and clinical features of the 45 patients included in the study are listed in the table I. Overall, mean hematoma volume was 18.38±25.32 (range=0.72-129.25), whereas the mean time from symptom onset and CT perfusion scanning was 10.10±4.90 hours (range=2.44-21.24 hours; median=9.42 hours).

CT perfusion measurements

Mean rCBF and rCBV levels were significantly lower in hemorrhagic core (10.308±6.851ml/100g/min and 0.828±0.456ml/100g, respectively) than in perihematomal low density area (34.506±15.784ml/100g/min and 2.25±0.927ml/100g, respectively) ($p<0.001$), and in perihematomal area than in normal appearing area

TABLE I. – Demographic and clinical characteristics in 27 patients with acute spontaneous intracerebral hemorrhage (SICH).

TABLEAU I. – *Caractéristiques cliniques et démographiques de 27 patients avec hématome intracérébral spontané.*

Sex (male/female)	22/23
Mean age, years	69.89 ± 10.07
Mean admission Glasgow Coma Scale (range)	13.8 ± 1.2 (12 – 15)
SICH location	
Basal ganglia	27
Lobar	18