Journal of Vascular and Interventional Neurology
Official journal of Zeenat Qureshi Stroke Research Center

Reversal of CT hypodensity after acute ischemic stroke

Michael Yannes[1], **Jennifer V. Frabizzio, MD**[1], and **Qaisar A. Shah, MD**[1]
[1] *Abington Memorial Hospital in Abington, Pennsylvania*

Abstract

We report a man admitted to the hospital after sustaining an ischemic stroke, with a return to isodensity on repeat computed tomography (CT) scan noted at day 9 of his hospital stay. This finding, known as the "fogging effect," has never been noted so early in a patient's course on CT imaging.

CT	computed tomography
MRI	magnetic resonance imaging

Introduction

Stroke is the third leading cause of death and is a major contributor to morbidity and mortality in the United States [1]. This substantial figure makes the diagnosis of stroke in the acute setting incredibly important. While advances in imaging and intervention have boosted the identification and survival rate from stroke, the diagnosis of stroke remains a clinical one.

Even though the importance of imaging in the acute stroke setting and beyond cannot be overstated, there are important limitations to its usefulness. Specifically, as an ischemic brain injury heals, it can transition from a radiologically hypodense region to a radiologically isodense region. This transition has previously been thought to occur roughly 2- to 3 weeks after an infarction using computed tomography (CT), and has been termed the "fogging effect."

First identified in 1979 [2], this effect can mask a late diagnosis of stroke, as well as muddle the ability to quantify the boundaries of an infarct's territory weeks later. Thus, better understanding of the timing and qualities of this "fogging effect" is of paramount importance in the clinical course of stroke management.

Case report

An 83-year-old man with a past medical history of atrial fibrillation, hypertension, diabetes mellitus type II, dyslipidemia, chronic kidney disease on hemodialysis, stroke, and chronic obstructive pulmonary disease (COPD) presented to the emergency department with an acute onset of right hemiplegia and expressive aphasia (National Institutes of Health Stroke Scale [NIHSS] 24). He stated to have felt "strange" in the early morning (1 AM), but first noticed his symptoms upon waking in the morning. International normalized ratio (INR) was 1.3 at the time of admission.

A non-contrast CT scan of the head was performed, which depicted no evidence of intracranial hemorrhage (ICH) or mass effect (Figure 1). A subsequent CT angiogram demonstrated possible occlusion of the left middle cerebral artery (MCA). CT perfusion was inconclusive secondary to poor cardiac ejection fraction. The nebulous onset of his symptoms was a contraindication to the administration of intravenous recombinant tissue plasminogen activator (IV tPA), and the patient was taken for mechanical thrombectomy of the left MCA. The procedure was completed without complication. Complete revascularization was achieved within approximately 24 min. The patient was transferred to the intensive care unit (ICU) under stable neurological condition.

Sixth day CT scan of the head demonstrated evolved, hitherto undocumented radiographically, infarction in the left basal ganglia (Figure 2). Repeat CT scan obtained on day 9, demonstrated marked improvement in the hypodensity, to the point of apparent isodensity (Figure 3).

The patient was ultimately restarted on coumadin and discharged to a rehabilitation center. At his 2-month follow-up, he reported improvements in weakness and communication, and was noted to have an NIHSS of 4, modified Rankin Scale (mRS) of 2.

Published June, 2013.

*Correspondence to: QA Shah, Tel.: +1-215-481-3145, Fax: +1-215-481-5971, Email: qaisarshah@gmail.com. All authors have contributed equally to this work. There are no financial sponsorships or potential conflicts of interest to disclose.

Journal of Vascular and Interventional Neurology

Figure 1. Non-contrast head CT scan on admission; no evidence of infarction or hemorrhage noted.

Discussion

The “fogging effect” was first described by Becker and colleagues in 1979 [2]. The group recognized the transformation of hypodense lesions to isodense lesions on CT after a period of 2- to 3 weeks in patients with ischemic strokes. They correlated this observation to the resorption stage of Spatz’s classification [3], and believed that it was a common pathway of stroke healing. Current research now suggests that this finding relates to the process of macrophage invasion, proliferation of capillaries, and sometimes extravasation of blood cells through damaged vessel walls. During this time, the acute edema phase of stroke has resolved, but the tissue cavitation phase has not yet occurred [4]. Skriver and colleagues attempted to study the incidence of the “fogging effect,” and found an incidence of 54% of all ischemic stroke patients using CT [5]. They agreed with Becker et al suggesting that such findings can be seen on CT 2- to 3 weeks after an initial ischemic event. Fogging was first noted using magnetic resonance imaging (MRI) in 1991 [6]. The incidence of this effect was noted to be approximately 50% of all acute stroke patients [7]. A positive fogging effect has been associated with a better prognosis. Furthermore, recent data suggests that fogging occurs between 6- and 36 days using MRI, with a median of 10 days post-stroke [7]. The “fogging effect” seen with both MRI and CT scan leads to an underestimation of an infarct’s extension in the subacute stage, which requires later examinations to infer true size. Fur-

Journal of Vascular and Interventional Neurology

Figure 2. Non-contrast CT scan of the head (day 6 of hospital stay), demonstrating hypodensity within basal ganglia suggesting infarction (circle).

thermore, this effect can lead to false-negative follow-ups, which affects clinical care [8]. Thus, early imaging, sequential review of all prior imaging studies, and knowledge of imaging limitations can help to improve clinical outcomes.

Interestingly, there are no current recommendations related to stroke imaging in this subacute time period [1]. While the benefit of early imaging in acute stroke is widely documented, the use of imaging to document either resolution or extension is less studied. This is unfortunate; although a vast majority of strokes are seen acutely through imaging, there have been reports of strokes not appearing (or possibly being hyperacutely "fogged") radiologically until weeks after initial presentation [9]. Given this information, deference should be given to the statement that stroke remains a clinical diagnosis. Prior studies have suggested that contrast enhancement may be of benefit, as 60–65% of stroke patients 1–4 weeks after the initial event show gyriform enhancement [10]. However, routine post-contrast imaging is not often used. More research should be conducted to establish effective methods to document ischemic injury in the subacute time period.

One notable consideration regarding this case includes the possibility that this reversal of hypodensity could be secondary to resolution of vasogenic edema. Such rapid changes in radiographic findings are not consistent with the course of vasogenic edema. In cases involving neurointervention specifically, resolution of vasogenic edema is more likely to occur on post-operative day 2 or 3, not on days 6 through 9, as seen in this patient.

In this case study, there was a return to isodensity on repeat CT imaging as soon as 9 days after the onset of

Journal of Vascular and Interventional Neurology

Figure 3. Non-contrast CT scan of the head (day 9 of hospital stay); demonstrating improvement in the hypodensity noted earlier (arrows).

acute ischemic stroke. Although prior research had suggested the ability for MRI to recognize the "fogging effect" as soon as 6 days after the inciting event, there have been no reports suggesting that a "fogging effect" can occur this early using CT. This observation makes the importance of early clinical recognition of stroke and early imaging of paramount importance.

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Journal of Vascular and Interventional Neurology