

THE ROLE OF COMPUTED TOMOGRAPHY IN EVALUATION OF THE ACUTE ISCHEMIC STROKE

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ULOGA KOMPJUTERIZOVANE TOMOGRAFIJE U EVALUACIJI AKUTNOG ISHEMIJSKOG MOŽDANOG UDARA

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ABSTRACT

A stroke is a sudden loss of brain function which happens due to the disruption of cerebral blood flow. It is characterized by expeditious development of clinical symptoms during the first few minutes or hours after which the symptoms progress and in some patients lead to death. In more than 80% of patients with stroke, the cause is vascular insufficiency and this type of stroke is called ischemic. It is an emergent condition which needs accelerated management so that optimum care and prognosis can be reached. Evaluation of the ischemic stroke is managed with noncontrast computed tomography in most cases, thanks to its widespread availability.

A detailed literature search through the Medline and Ebsco databases was performed, using the following terms: (computed tomography) AND (acute ischemic stroke) AND (early signs). We selected original investigations, meta-analyses and reviews from the past 10 years, with accessible full-texts, in the English language, as well as significant reference lists of articles which could contribute to the readers' comprehension. After a detailed review of the literature, we have segregated and described the following early signs in acute ischemic stroke: insular ribbon sign, obscuration of the lentiform nucleus, hyperdense artery sign, hemispherical sulcal effacement and focal hypoattenuation. These signs are related to the consequences of cellular hypoperfusion and cytotoxic edema.

The aim of this paper was to review the literature regarding the role of computed tomography in patients with early signs of acute ischemic stroke and to serve as an educational material that illustrates those findings.

Key words: tomography, X-ray computed; brain infarction; signs and symptoms.

INTRODUCTION

A stroke is a sudden loss of brain function which happens due to the disruption of cerebral blood flow (1). The stroke is characterized by expeditious development of clinical symptoms during first few minutes or hours after which symptoms progress and in some patients lead to death (2). In more than 80% of stroke, the cause is vascular insufficiency and this type of stroke is called ischemic (3). Main cause of ischemic stroke is

SAŽETAK

Moždani udar je nagli gubitak funkcije mozga koji se dešava zbog prekida cerebralne cirkulacije. Odlikuje se ekspeditivnim razvojem kliničkih simptoma tokom 24 sata, koji kod nekih pacijenata dovode do smrti. Kod više od 80% pacijenata sa moždanim udarom uzrok je vaskularna insuficijencija i ova vrsta moždanog udara je ishemijska. To je hitno stanje kod kojeg je neophodno ubrzano zbrinjavanje radi optimalne prognoze. Evaluacija ishemijskog moždanog udara u većini slučajeva postiže se kompjuterizovanom tomografijom, bez upotrebe kontrasta, zahvaljujući njenoj širokoj upotrebi.

Detaljna pretraga literature kroz Medline i EBSCO baze podataka obavljena je korišćenjem sledećih ključnih reči: kompjuterska tomografija, akutni ishemijski moždani udar i rani znaci. Izabrani su originalni radovi, metaanalize i pregledni papiri za poslednjih 10 godina, sa pristupačnim tekstovima na engleskom jeziku, kao i značajne reference koje mogu da doprinesu shvatanju čitalaca. Nakon detaljnog pregleda literature izdvojili smo i opisali sledeće rane znake akutnog ishemijskog moždanog udara: znak insularne trake, potamnjenje nucleus lentiformisa, znak hiperdenziteta arterija, hipodenzitet hemisfera i fokalna hipoaenuacija. Ovi znaci su povezani sa posledicama ćelijske hipoperfuzije i citotoksičnim edemom.

Cilj ovog rada bio je pregled literature o ulozi kompjuterizovane tomografije kod pacijenata s ranim znacima akutnog ishemijskog moždanog udara, koja treba da posluži kao edukativni materijal koji ilustruje te nalaze.

Ključne reči: tomografija, X-zracima kompjuterizovana; infarkt mozga; znaci i simptomi.

cerebrovascular thromboembolism (2, 3). In other cases, around 15% of them, there is a cerebral blood vessels rupture which leads to hemorrhagic stroke (intracerebral hemorrhage) (3, 4). Stroke is a global issue and it takes a prominent place in the matter of adult mortality and morbidity (2, 3). Stroke mortality in Europe and United States is on third place, which makes it economic burden (3, 5).

The main cause of stroke is occlusion of cerebral artery, which leads to fast brain tissue death (6). Tissue surrounding the stroke center is viable thanks to the

collaterals (7). This area, ischemic penumbra, is hypoperfused at the beginning, but it can be rescued later on (8). The recovery of neurons is possible only if cerebral blood flow (CBF) stays above 10 to 15 mL/100 g tissue/min (9). Previous studies have shown that brain fights the hypoperfusion by increase of oxygen extraction (6). If CBF falls under the threshold, a Na⁺/K⁺ channel failure takes place which leads to unrestrained shift of extracellular water in the intracellular space of ischemic cells or better known "cytotoxic edema" (7-9). The size of the stroke core and penumbra depends on degree of CBF decrease and reperfusion (10). Penumbra can be saved from infarction with early recanalization, either spontaneously or due to thrombolysis (11, 12). Individually, penumbra survival varies from less than 3 hours to well beyond 48 hours (11, 13, 14).

Stroke usually involves transient ischemic attack (TIA), which is a brief neurological dysfunction caused by focal cerebral or retinal ischemia (15). Hyperacute stroke patients are those with clinical presentation of symptoms in 6 hours window frame, after the onset of stroke (16). It is an emergent condition which needs accelerated management so that optimum care and prognosis can be reached (17). In this case, the care requires evaluation, stabilization and therapy in 6 hours window frame (16, 17). Evaluation of the ischemic stroke is managed with noncontrast computed tomography (CT) in most cases, thanks to the presented early signs and their proper recognition (9, 18).

The aim of this paper was to review the literature regarding the role of computed tomography in patients with early signs of acute ischemic stroke and to serve as an educational material that illustrates those findings.

MATERIALS AND METHODS

A detailed literature search through the Medline and Ebsco databases was performed, using the following terms: (computed tomography) AND (acute ischemic stroke) AND (early signs).

We selected original investigations, meta-analyses and reviews from the past 10 years, with accessible full-texts, in the English language, as well as significant reference lists of articles which could contribute to the readers' comprehension.

THE ROLE OF COMPUTED TOMOGRAPHY IN IMAGING OF ACUTE ISCHEMIC STROKE

The central place in diagnosis and management of acute ischemic stroke (AIS) to date, has non-contrast computed tomography (NCCT) (9, 19). At the beginning, CT was used for brain imaging and thus, it found place in

cerebrovascular diagnostics (20-22). Its use is widespread and also short scan time, noninvasiveness and safety, make it the first-line in imaging of acute ischemic stroke (9, 10). The key fact in NCCT use is that it can be performed in a matter of seconds to evaluate hemorrhage and it can exclude other conditions that mimic the stroke, such as hypertensive bleeding, arteriovenous malformations, tumors etc. (9, 23). Perfusion-CT has a task in imaging of hemodynamics on capillary level and brain parenchyma (24, 25). CT angiography gives an insight in embolus existence, level of circulatory disruption and eventually, existence of collaterals (26, 27). Development of magnetic resonance imaging (MRI) with diffusion and perfusion sequences, brought a revolution in AIS imaging but the role of CT still can't be ruled over due to its wide availability, fast acquisition of images and simple use (28-30).

The aim of early NCCT evaluation is to make a distinction between ischemic stroke and cerebral hemorrhage (28). Proven beneficial therapy for AIS patients is intravenous thrombolysis with recombinant tPA, but in order to be applied patients must be carefully evaluated (17, 28, 31). Thrombolysis is limited to the first 3 to 4.5 hours after symptom onset (17). Disregard of this rule usually leads to new and probably fatal hemorrhage in the area of infarction. This is why, rapid diagnosis must be brought. NCCT diagnosis of infarction which takes more than one third of middle cerebral artery (MCA) area and/or intracranial hemorrhage should not be given thrombolytic therapy (32). It is strongly recommended by current guidelines that patients with suspected TIA undergo CT, or MRI if urgently available (28, 33-35). In addition to the diagnostic modalities, interventional neuroradiology procedures have crucial place in therapeutic approach of stroke patients during appropriate "window frame" (33, 34).

The use of computed tomography is mostly condemned because of the radiation and iodinated contrast (9, 19). However, in such acute conditions, the proper diagnosis must take first place. Newer technologies delivered us a multidetector CT scanners with full brain coverage in a single rotation (36). This can be essential in evaluation of acute conditions such as ischemic stroke and that is why improvements in this area should be made, especially regarding the reduction of radiation doses by use of low dose imaging (37, 38).

Detection of early signs

Early CT signs of brain ischemia include focal or hemispherical hypoattenuation (hypodensity), insular ribbon sign, obscuration of the lentiform nucleus, sulcal effacement and hyperdense arteries (28). These signs are related to consequences of cellular hypoperfusion and

cytotoxic edema and the last one points on thrombosis of specific blood vessel (28,39).

Focal or hemispherical hypodensity sign is presented with hypoattenuation of the brain parenchyma, due to the cytotoxic edema (9). It is found in 20% to 60% of acute stroke cases (28, 40). It can be present in the cases of watershed ischemia in the area of bordering arteries (41). The identification of this sign during early stroke is difficult but it can be improved by radiologist's active approach and alteration of "window-width" and "center-level" rates. If this sign appears earlier, the prognosis is worse (40, 42).

Loss of insular ribbon sign is defined as lessening precision in delineation of gray-white matter interface at lateral margin of insula (39). It is prevalent in infarction of the MCA (or internal carotid artery) territory and reported to be present in 75-100% of the cases (9). The insular segment of the MCA and its claustral branches supply the insular ribbon and because of a lack of collaterals (watershed zone), it is especially sensitive on the occlusion of specific MCA part (28). Insular ribbon sign rarely appeared alone and more than 50% of patient with it also had obscuration of basal ganglia and effacement of the hemispherical sulcus. The concomitant presence of these three signs point on internal carotid artery (ICA) occlusion and bad prognosis (40, 43).

The obscuration of the basal ganglia (lentiform nucleus) is one of the earliest sign in patients with AIS, in some patients happens within first hour, while 73-92% of patients had it within 6 hours of stroke onset (28, 44). When ischemic, an obscured outline or partial disappearance of the lentiform nucleus can be seen on NCCT (39). This sign is described as decreased attenuation involving the basal ganglia which was explained with the vulnerability of basal ganglia due to the lack of collaterals (9). Because of that, this sign appears with ICA or M1 segment of MCA occlusion (9). However, if the embolic occlusions had been in more distal part of the MCA or in other arteries, CT may not show abnormality in the basal ganglia at all (21).

Hemispherical (cortical) sulcal effacement sign is defined as decreased contrast, loss of precise delineation of the gray white interface in the margins of cortical sulci thanks to the edema in ischemic tissue (45). It appears with other signs, usually with the hip density sign or isolated as cortical infarction which has better prognosis (28, 43, 40).

Hyperdense artery sign presents a thrombotic event or better say, linear or eventually dot change in the arterial lumen (9). The incidence of this sign varies between 5%-41% (45). Hiperdensity is usually seen in MCA lumen but it is also described in other arteries (ICA, posterior cerebral artery and anterior cerebral artery) (26, 46, 47). The presence of an acute thrombus in the proximal part of

MCA creates a linear hyper-attenuation on NCCT, and in distal parts of MCA it is described as dot sign (48, 49). The first one is connected with severe neurological deficit and bad prognosis, while the other one has lighter form (14). In the interpretation of hiperdensity sign, caution is needed, because the high density can be a result of calcified arteriosclerosis and high hematocrit values (50, 51).

The recognition of acute ischemic stroke and its early signs is crucial for physicians and patients. The role of the early CT signs is great but the proper interpretation of the image and consideration of patients clinical image are necessary as well as physician's experience in this field (40,52). The mean sensitivity and specificity of physician's reliability detection of early CT signs were 55% (range 20-87%) and 87% (range 56-100%) respectively (39). Also, there are disagreements in identification of these changes (28).

In conclusion, it is important to improve detection of early signs in acute stroke in non-contrast computed tomography, which is still the imaging of choice. This can happen only with continuously education and training of physicians. Given the fact that stroke is third leading cause of death in Europe, this should be an imperative for radiologists and neurologist.

ABBREVIATIONS

- CBF - cerebral blood flow
- TIA - transient ischemic attack
- CT - computed tomography
- AIS - acute ischemic stroke
- NCCT - non-contrast computed tomography
- MRI - magnetic resonance imaging
- MCA - middle cerebral artery
- ICA - internal carotid artery

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