The "dense artery sign" – major cerebral artery thromboembolism demonstrated by computed tomography

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Summary. A 4 years review of high resolution thin slice (3–5 mm) computed tomography performed within 24 h after cerebral infarction revealed increased density in a major cerebral artery segment in 28 patients. Arteries affected were the vertebral and basilar artery in 6 and 8 patients, the sphenoid course of the middle cerebral artery in 13 cases and the extracranial internal carotid artery in 1 patient. In 35.7% of cases the so called “dense artery sign” provided earliest evidence of the ensuing infarction documented by CT controls in most patients. Angiography carried out in 8 patients, density calculatins in the course of the affected vessel and resolution of the increased density on subsequent CT examinations suggest thrombembolism as the most likely etiology. In the clinical setting of acute stroke increased artery density encompassing the entire vessel diameter may serve as an early indicator of major cerebral artery occlusion and prompt angiographic investigation of a lesion potentially amenable to lysis.

Key words: Cerebral infarction – Thrombembolism – Computed tomography – Density quantification – Magnetic resonance imaging

In the acute stage of ischemic stroke early CT findings known to evolve within 12–24 h after the ictus consist of effacement of sulci and the development of a poorly defined hypodense area [1–3]. Positive CT findings reported in 80% of supratentorial infarction within 24 h [4] are less frequently encountered in the posterior fossa [5–7] where degrading artifacts may obscure subtle changes apt to appear on the initial scan. Increased density in a majoral cerebral artery is an early positive CT sign of infarction. It has been reported in a few instances in the context of acute stroke, predominantly in the middle [8–12], and anterior cerebral artery [12]. To our knowledge CT visualization of a high density in the vertebral or basilar artery has scarcely been recognized. Recognition of this sign is of particular therapeutic importance, as it might advise the neuroradiologist to proceed to further angiographic investigation of a lesion potentially amenable to systemic or local lysis.

Methods
The CT scans of a 4 year period (1984–88) performed on a high resolution scanner (GE 9800) within 24 h after cerebral infarction were investigated. CT examinations carried out on a 2nd generation scanner during the early study period, examinations degraded by motion artifacts or with insufficient clinical information as to the time course of ischemia were excluded. In 121 patients infarction following major cerebral artery or branch occlusion was suspected. 28 patients were observed to harbor increased density in a major cerebral artery on the initial scan. CT controls were available in all but 3 cases showing the development of an area of infarction and the disappearance of the increased density. Prior to the study special attention had been drawn to the foramen magnum as baseline of slice position in cases with presumed vertebro-basilar system cerebral infarction. Slice thickness was 3 to 5 mm in the posterior fossa and the basal cisterns, 10 mm in the remainder of the brain above the basal ganglia level.

In order to determine whether the "dense artery sign" was not a relative phenomenon due to diminished density in the surrounding brain parenchyma, or simply reflected atherosclerotic vessel walls, the attenuation values in the course of the affected artery were calculated in 9 patients. Three adjacent regions of interest of one pixel size (to mi-
Results

CT examinations performed on a high resolution scanner within 24 h after acute stroke revealed increased density in a major cerebral artery in 28 patients, 14 males (mean age 49.6 years) and 14 females (mean age 58.5 years). Ages ranged from 21 to 76 years.

15 patients presented with a predominant motor and/or sensory hemisindrome, two patients with cerebellar signs. Major brainstem syndromes were observed in 11 patients including 2 with Wallenberg's dorsolateral medullary syndrome. An unfavorable prognosis, mortality being 50%, was linked to a definite decreased level of consciousness present in 18 patients on admission. Overall hospital mortality was 9/28 (32.1%), but was found to vary considerably from 1/6 (16.6%) and 4/13 (30.8%) in presumed vertebral and middle cerebral artery occlusion to 50% (4/8) in basilar artery thrombosis.

CT visualization of thrombembolism was suggested in 27 vessels intracranially, and in 1 patient at the base of the skull.

The CT-findings on the day of ictus are depicted in Table 2.

A positive “dense artery sign” was the only initial CT finding in 10 patients (35.7%). Follow-up examinations showed an area of infarction to develop in every patient. Increased artery density was encountered as an important corroborative sign of early infarction in an additional 18 patients (64.3%). A mortality rate of 20% vs 38.9% (7/18) appeared to reflect a more favorable prognosis for those 10 patients, who initially presented with normal tissue density. But interpretation has to take into account, that early institution of local lysis therapy improved prognosis in 2 out of 3 patients with basilar artery thrombosis and probably in 2 out of 4 patients with vertebral artery occlusion with no death occuring in the latter group. In cases with presumed middle cerebral artery thrombosis initially normal parenchymal density was due to early CT examination, ranging form 5 to 9 h after the ictus.

Hemorrhagic transformation of the ischemic area was noticed in 4 cases with middle cerebral artery infarction on the 1st, 3rd, 7th and 17th day respectively. Marked midline shift occurred in 7 patients between the 3rd and 6th day after middle cerebral artery occlusion, and was found to be an ominous sign in 4 cases. In order to differentiate the “dense artery sign” from atherosclerosis and “normal” vessel density, density measurements were performed in the aforementioned fashion (see Methods). The results are shown in Fig. 1.

The following conclusions can be drawn from the graphs:

- A typical density profile with mean CT numbers ranging from 77 to 89 HU (Hounsfield Units) was calculated for those vessels that were recognized as segments of increased density on the non-contrast scan (Graph A; Fig. 2)
- Mean normal artery density was within a range of 42 to 53 HU (Graph B), calculated from 3 adjacent regions of interest in the course of the vessel
- Varying mineral content in atherosclerotic plaques appeared to account for considerable density differences reflected by HU numbers that covered a spectrum from 114 to 321 HU (Graph C).