Factors Affecting Attenuation of Dural Sinuses on Noncontrasted Computed Tomography Scan

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Background and Purpose: Noncontrasted computed tomography (NCCT) is used as the initial neuroimaging test of choice for patients who present with new-onset neurological symptoms. An apparently hyperattenuated venous sinus may lead to the suspicion of cerebral venous sinus thrombosis (CVST). Improved understanding of all factors that can affect attenuation of dural sinuses can guide triage of patients to or from further investigations of suspected CVST. The purpose of this retrospective study was to assess the effect of different factors including hematocrit (HCT), hemoglobin (Hb), age, BUN/Cr ratio (blood urea nitrogen-to-creatinine ratio), and gender on the attenuation of dural sinuses on brain NCCT. *Methods:* A total of 1293 patients with neurological symptoms who presented to the emergency department were included in this study. For each patient, clinical assessment, laboratory investigations, and brain NCCT were reviewed. For each brain NCCT, the average attenuation of superior sagittal sinus and both right and left sigmoid sinuses was measured. *Results:* Positive significant correlations were found between average attenuation of dural sinuses on one hand and each of age, Hb, and HCT on the other hand. No significant correlation was found between average attenuation and BUN/Cr ratio. Gender discrepancy was also significant as higher attenuation was found in men. *Conclusion:* Age, gender, and Hb levels are the main factors that should be taken into account upon the assessment of dural sinuses on brain NCCT. The highest normal attenuation is predicted in an elderly polycythemic man and the lowest is predicted in a young anemic woman.
Key Words: Cerebrovenous sinus thrombosis—noncontrasted CT—dural sinuses—attenuation—age.

Introduction

Cerebral venous sinus thrombosis (CVST) is a challenging neurologic disorder that represents approximately 0.5% of all stroke cases worldwide.[1] The symptoms and clinical features are nonspecific leading to a highly variable presentation among different age groups, making the diagnosis of CVST mainly based on a high index of clinical suspicion and imaging confirmation. Despite being a rare neurologic disorder, with an annual incidence estimated at 2-7 cases per 1 million populations,[2] mortality rates of 10% have been reported among CVST patients,[1] making early diagnosis and treatment very critical.

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Noncontrasted computed tomography (NCCT) scan is widely used as the initial neuroimaging test of choice for patients who present to the emergency department with new-onset neurological symptoms such as headache, seizures, mental alteration, or focal neurological signs.[3] As subjective assessment of the radiodensity based on apparent increase or decrease in attenuation may be misleading,[2] radiologists tend routinely to measure the attenuation of intracerebral structures on brain NCCT by means of Hounsfield units (HU), where observing a dural sinus with an elevated HU value (i.e., hyperattenuation) may lead to the suspicion of CVST.[4] These hyperattenuation signs have a crucial role in detecting CVST at an early stage when treatment is most likely to be effective and to greatly affect the clinical outcome.[5] The drawback of these signs is that many factors can affect the degree of attenuation of blood, therefore confusing normality with pathologic conditions and thus increasing the number of false-positive and false-negative readings upon interpretation of NCCT.

Improved understanding of all factors that can affect attenuation of dural sinuses can guide triage of patients to or from further investigations of suspected CVST. Despite the crucial role of NCCT, still minimal information is known about these factors. Hemoconcentration and dehydration have long been assumed as known factors to increase the attenuation of blood on NCCT,[2,4,6] but the correlation with many other factors is not established yet. The purpose of this retrospective study, which included one of the largest samples of control population ever used for the same purpose, is to assess the effect of different factors including hematocrit (HCT), hemoglobin (Hb), age, BUN/Cr ratio (blood urea nitrogen-to-creatinine ratio), and gender on the attenuation of dural sinuses on brain NCCT.

Methodology

This retrospective study was approved by our institutional review board; patient informed consent was waived.

Patients

A total of 1580 patients who presented to the emergency department in our tertiary hospital in the period between June 28, 2014, and September 5, 2015, were recruited in this study; clinical assessment, laboratory investigations, and NCCT of brain were reviewed for each patient.

To meet our inclusion criteria, (1) each patient was presented with new-onset neurological symptoms such as headache, seizure, mental alteration, or focal neurological signs; (2) NCCT scan, complete blood count (CBC), and kidney function test (KFT) were done within 24 hours of onset of symptoms; and (3) diagnosis of CVST was excluded by magnetic resonance venography (MRV), or diagnosis other than CVST was established.

The following were the exclusion criteria: (1) clinically dehydrated patients as indicated in their hydration assessment sheet; (2) hemorrhage or skull fracture adjacent to dural sinuses, severe brain swelling, intra-axial or extra-axial mass, contrast media administration within the previous 24 hours, or patients who received blood transfusion within the previous 24 hours; and (3) neonates below 6 months in order to eliminate the effect of fetal Hb.

Up to 1293 patients were included in our study. Of these patients, 286 were excluded according to our criteria: 142 patients due to clinical dehydration; 93 due to head pathologies mentioned in criteria #2; and 51 due to age less than 6 months, with only 1 excluded due to CVST confirmed by MRV. Male–female difference was not significant as 671 (51.9%) were male and 622 (48.1%) were female.

Of the 1293 patients included, 413 presented with various neurological signs and symptoms including headache, dizziness, nausea, and vomiting without focal neurological signs; they had normal CT and normal magnetic resonance venography later on (so CVST was excluded). Two hundred five patients had focal neurological signs and negative CT, had their MRI done, and showed an infarction; furthermore, other 162 patients had focal neurological signs and negative CT and MRI and diagnosed with transient ischemic attack. Up to 164 patients presented mainly with headache and diagnosed with sinusitis on CT. One hundred seventeen patients presented with neurological signs and symptoms with fever and negative CT and diagnosed with lumber puncture with meningitis. One hundred nine patients presented with headache and high blood pressure, had their brain CT done, and showed no brain hemorrhage. One hundred twenty-three patients presented with neurological symptoms and found to have other system-related infections.

Data Interpretation

Attenuation of superior sagittal sinus and both left and right sigmoid sinuses was measured by 1 specialized radiologist in order to eliminate interobserver variation, 1 region of interest (ROI) measuring 2-mm recorder used to measure attenuation of each sinus in HU, except in small nondominant sigmoid sinuses in which we used an ROI of 1 mm. The average sinus density was calculated by taking the mean of density of superior sagittal sinus and both left and right sigmoid sinuses.

Hb and HCT were obtained from CBC whereas Cr and BUN were obtained from the KFT. BUN/Cr ratio was calculated. The Hounsfield number of superior sagittal sinus to HCT level (H:H ratio, Hounsfield unit-to-hematocrit ratio) was calculated.

Imaging Protocol

All images were done via Siemens, Somatom Definition Flash 128 slice, CT scanner (Siemens Medical Solutions, Forchheim, Germany), with the following parameters: 360-410 mAs, 120 kV, section thickness of 5 mm, and reconstruction increment of 5 mm.