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The Role of Multidetector CT Venography in Diagnosis of Cerebral Venous Sinus Thrombosis

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Abstract: Cerebral venous thrombosis is a disorder that is challenging to diagnose. The diagnostic difficulty results in large part from the wide variety of clinical manifestations of this uncommon disorder. Twenty patients were diagnosed as having cerebral sinovenous thrombosis on CT venography were included in this study.They were 13 males and 7 females and their age ranged between 31 to 66 years. All CT venography was performed on an MDCT scanner with an Advantage Windows 3D workstation. A routine unenhanced CT scan was obtained with 5-mm-thick contiguous axial sections from the base of the skull to the vertex, followed immediately by CT venography A total of 70-80 mL of nonionic contrast material (iodixanol, 270 mg I/mL) was administered at a rate of 3-4 mL/s by a power injector into an antecubital vein. The preliminary unenhanced CT scans showed that of these 20 pateints 12 patients had hemorrhagic infarctios , 6 patients had nonhemorrhagic infarctions and 2 pateints showed normal parenchyma.. The empty delta sign was seen in 5 patients on the enhanced CT scans. The results of this study showed that the sinus most frequently involved was the superior sagital sinus in 13 patients.Of 13 patients with superior sagital sinus thrombosis, 5 patients also had associated transverse sinuse thrombosis and 4 patients had associated thrombosis of sigmoid sinus.Eight patients showed transverse sinus thrombosis. Seven patients showed sigmoid sinus thrombosis.Two patients showed straight sinus thrombosis. One patient showed throbosis of vein of Galen's. In conclusion cerebral venous sinus thrombosis could be easily visualized and diagnosed by CT venography. CT venography is a fast, widely accessible, and cost-effective alternative to MR imaging, especially in the emergency setting.

Key words: Multidetector CT Venography, diagnosis, cerebral venous sinus thrombosis

INTRODUCTION

Cerebral venous thrombosis is a disorder that is challenging to diagnose. The diagnostic difficulty results in large part from the wide variety of clinical manifestations of this uncommon disorder. Because of the great diversity of clinical features, its unforeseeable evolution, and a small proportion of cases that will worsen in the acute phase, cerebral venous thrombosis must be diagnosed as early as possible so that specific treatment can be started, typically transcatheter thrombolysis or systemic anticoagulation[1].

Magnetic resonance (MR) imaging, un-enhanced computed tomography (CT), unenhanced time-of-flight MR venography, and contrast material–enhanced MR venography and CT venography are particularly useful techniques for detecting cerebral venous and brain parenchymal changes that may be related to thrombosis[2].

Unenhanced computed tomography (CT) is usually the first imaging study performed on an emergency basis. Unenhanced CT allows detection of ischemic changes related to venous insufficiency and sometimes demonstrates a hyperattenuating thrombosed dural sinus or vein. Helical multidetector CT venography with bolus power injection of contrast material and combined use of two-dimensional and three-dimensional reformations (maximum intensity projection, integral display, and volume rendering) provides exquisite anatomic detail of the deep and superficial intracranial venous system and can demonstrate filling defects. However, common variants of the sinovenous system should not be mistaken for sinus thrombosis. A comprehensive diagnostic approach facilitates imaging of cerebral venous thrombosis with multidetector CT[3&4].

CT venography has proved to be a reliable method to investigate the structure of the cerebral veins, with a reported sensitivity of 95% with multiplanar reformatted (MPR) images when compared with digital subtraction angiography (DSA) as the standard of reference. Owing to its vascular detail and ease of interpretation, CT venography can provide a rapid and reliable diagnosis of cerebral venous thrombosis[5].

The aim of this study is to evaluate the role of multidetector CT venography in diagnosis of cerebral venous sinus thrombosis.

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MATERIALS AND METHODS

The study was performed over two years .Thirty five patienrs who were clinically suspected of having cerebral venous thrombosis(CTV) underwent preliminary unenhanced CT followed by CT venography.Of these 35 patients with clinically suspected CTV, 20 were diagnosed as having cerebral sinovenous thrombosis on CT venography and were included in this study.They were 13 males and 7 females and their age ranged between 31 to 66 years.The patients presented by headache,obscuratin of vision,altered consciousness, nausea and vomiting and on examination they showed papilledema focal neurologic deficit and cranial nerve palsy.

All CT venography was performed on an MDCT scanner with an Advantage Windows 3D workstation. A routine unenhanced CT scan was obtained with 5-mm-thick contiguous axial sections from the base of the skull to the vertex, followed immediately by CT venography. The scanning direction was from vertex to skull base. Scans were angled parallel to a line drawn from the posterior margin of the foramen magnum to the superior margin of the orbit to exclude the lens. The scanning parameters used were a slice thickness of 2.5 mm at an interval of 1.25 mm. The gantry rotation speed was 3.5-7.5 mm per rotation using 120 kV and 250-300 mA. A prescan delay of 30-40 seconds was used with a display field of view of 23-25 cm. A total of 70-80 mL of nonionic contrast material (iodixanol, 270 mg I/mL) was administered at a rate of 3-4 mL/s by a power injector into an antecubital vein. Unenhanced CT scans of the patients were analyzed for parenchymal lesions and for the presence of the cord sign and the "dense vein" sign. CT venograms were analyzed for filling defects in the dural sinuses and for indirect evidence of CVT in the form of collaterals and tentorial enhancement. The source images were displayed with an approximate window setting of 400-450 H and a level of approximately 130-150 H to clearly visualize the dural venous sinuses separately from adjacent bone. The acquired CT data were processed using the Advantage workstation. Source images were reconstructed in coronal and sagittal planes using oblique multiplanar reconstruction (MPR) of appropriate window settings—a window width of 400-450 H and a level of 120-150 H—to separate sinuses from adjacent bones. Reformatted images were displayed using maximum intensity projection (MIP).

RESULTS AND DISCUSSION

Result: Twenty patients were diagnosed as having cerebral sinovenous thrombosis on CT venography.The preliminary unenhanced CT scans showed that of these 20 pateints 12 patients had hemorrhagic infarctios , 6 patients had nonhemorrhagic infarctions and 2 pateints showed normal parenchyma (table 1).

Unenhaced CT scans scans showed also that dense triangle sign was present in 7patients ,the cord sign was present in 2 patients and the rest 11 patients showed no venous abnormality (table 2).

The empty delta sign was seen in 5 patients on the enhanced CT scans

The results of this study showed that the sinus most frequently involved was the superior sagital sinus in 13 patients.Of 13 patients with superior sagital sinus thrombosis, 5 patients also had associated transverse sinuse thrombosis and 4 patients had associated thrombosis of sigmoid sinus. Eight patients showed transverse sinus thrombosis. Seven patients showed sigmoid sinus thrombosis. Two patients showed straight sinus thrombosis. One patient showed thrombosis of vein of Galen's (Table 3).

Discussion: Cerebral sinovenous thrombosis, or cerebral venous thrombosis (CVT), as a cause of serious neurologic symptoms and a fatal outcome was first prescribed in the early 19th century. The true incidence of CVT is unknown because of lack of adequate epidemiologic studies . Intracranial dural sinus thrombosis is a relatively common and potentially fatal condition. The diverse clinical presentations and lack of accurate diagnostic techniques have made CVT a difficult diagnosis with a grave prognosis. That milder forms of CVT can now be recognized and that most patients with CVT recover with recanalization of the thrombosed blood vessel have contributed to the decrease in mortality. Various radiologic techniques have been used to visualize the intracranial venous system. Conventional and digital subtraction cerebral angiography, CT, MRI, and recently, MR venography and CT venography have increased our ability to detect this condition[6,7].

The pathophysiology of brain parenchymal involvement in venous occlusion differs from that in arterial occlusion. Parenchymal changes may be secondary to cytotoxic edema, vasogenic edema, or intracranial hemorrhage. The primary underlying mechanism is likely to be increased venous pressure. If collateral pathways of venous drainage are insufficient, especially in the presence of cortical venous involvement, subsequent parenchymal changes may occur. If venous pressure continues to increase, with a consequent diminishment in arterial perfusion pressure, cell death may ensue. If adequate collateral pathways develop or recanalization occurs before cell death or intracranial hemorrhage, the parenchymal changes may resolve partly or completely. Vasogenic and cytotoxic edema patterns may coexist[8].

High-resolution CT has been reported to be comparable or superior to MR venography (2D-TOF or

Table 1: Unenhanced CT findings of parenchymal abnormality.

Unenhanced CT findings of parenchymal abnormality	No of pateints
Hemorrhagic infarctions	12
Nonhemorrhagic infarctions	6
Normal parenchyma	2

Table 2 : Unenhanced CT findings of venous abnormality.

Unenhanced CT findings of parenchymal abnormality	No of pateints
Dense triangle sign	7
Cord sign	2
No venous abnormality	11

Table 3: Showing the frequency of thrombosis of major sinuses on CT venography.

Sinus or vein throbosis	No of pateints
Superior sagital sinus	13
Transverse sinus	8
Sigmoid sinus	7
Straight sinus	2
Galen's vein	1

Fig. 1: Unenhanced CT showing bilateral high parietal hemorrhagic infarctions.

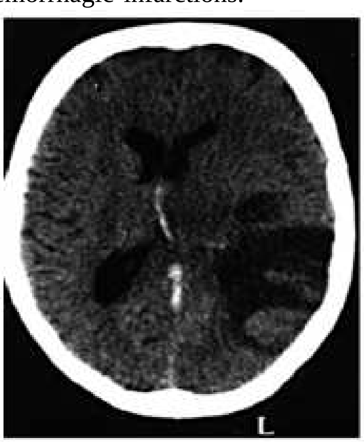

Fig. 2: Unenhanced CT scan Cord sign in the vein of Galen and internal cerebral vein.

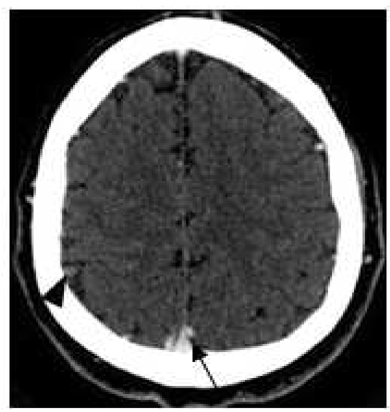

Fig. 3: Unenhanced CT scan showing cord sign oat right parital cortical vein(arrow head) & dense triangle sign at the superior sagital sinus (arrow).

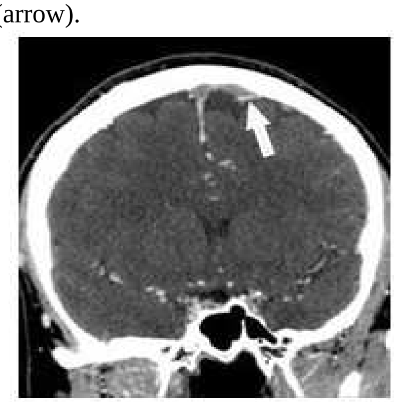

Fig. 4: Enhanced CT scan showing empty delta sign (arrow) in the superior sagital sinsus

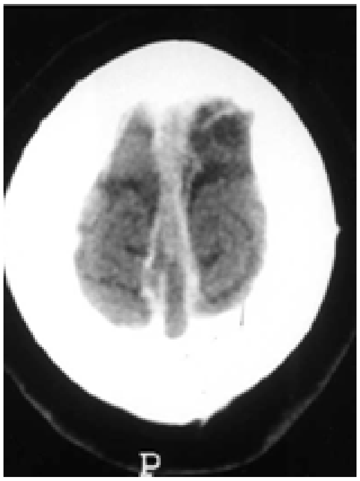

Fig. 5-A: CT angiography axial source image showing filling defct due non enhancing thrombus in superior sagital sinus

Fig. 5-B: CT venography :Throbus seen as filling defct in superior sagital sinus and small thrombi in adjacent cortical veins.

phase-contrast. CT angiography (CTA) is widely used for imaging intracranial arteries and veins. One disadvantage of conventional CTA is that time-consuming and operator-dependent editing is needed to remove overprojecting bone for the angiographic display of intracranial vessels. Recently a new, fully automatic masking technique called matched mask bone elimination (MMBE) was developed to remove bone pixels from CTA data sets[9].

Imaging findings of cerebral venous thrombosis can be categorized as direct, as when there is visualization of cortical or dural sinus thrombus, or indirect, as when there are ischemic or vascular changes related to the venous outflow disturbance.On the basis of the results of the largest cohort ever published (624 patients), collected over a short period of time, cerebral venous thrombosis involves the

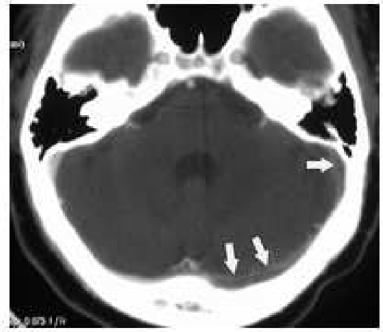

Fig. 6-A: Axial contrast-enhanced CT image shows thrombosis of the left transverse and sigmoid sinuses (arrows).

Fig. 6-B: CT angiography showing left transverse sinus throbosis.

following vessels in decreasing frequency: the superior sagittal sinus (62%), left and right transverse sinus (respectively 44.7% and 41.2%), straight sinus (18%), cortical veins (17.1%), deep venous system (10.9%), cavernous sinus (1.3%), and cerebellar veins (0.3%) . Most data about CT of cerebral venous thrombosis concern older conventional CT scanners. Technical limitations are related mainly to suboptimal enhancement and to the analysis of axial images with a narrow window level[1].

Indirect signs are not specific, but they should draw attention and prompt a search for direct visualization of a cortical or sinus thrombus. Early changes are often subtle, with brain edema and swelling of the gyri. Venous infarction manifests as a low-attenuation lesion with or without subcortical hemorrhage Brain lesions are related to a venous distribution. Bilateral parasagittal hemispheric lesions are suggestive of superior sagittal sinus thrombosis Ipsilateral temporo-occipital and cerebellar lobe lesions can be found in transverse sinus thrombosis. In bilateral thalamic lesions, deep cerebral venous thrombosis should be suspected Additional cerebral structures adjacent to the thalami such as the basal ganglia and the mesencephalon are affected in one-third of patients with deep cerebral venous thrombosis). Thrombosis of a deep cerebral vein can very rarely manifest unilaterally. After dural sinus thrombosis, transcortical medullary veins can become sources of collateral blood drainage. Subsequent dilatation of these vessels causes them to be visible at contrast-enhanced CT. Tentorial enhancement is caused by prominence of dural collaterals Small subdural hematomas or effusion are seen occasionally. Cerebral venous thrombosis rarely manifests as isolated subarachnoid hemorrhage of the convexity[10,11]

At unenhanced CT, a recently thrombosed dural sinus or cortical vein may be identified as an elongated hyperattenuating lesion The so-called dense triangle or cord sign represents an intravascular acute blood clot. This sign is reported in 20% of patients and takes approximately 1–2 weeks to disappear. However, similarly increased attenuation of the cerebral venous sinuses may also represent polycythemia and nonmyelinated brain in neonates makes sinuses appear unusually attenuating[12].

At contrast-enhanced CT, the thrombus does not enhance but the dura enhances When the thrombus is located in the superior sagittal and transverse sinuses, a triangular defect (empty delta sign) can be demonstrated on postcontrast images by using multiplanar reformations and window settings wider than those typically used for brain parenchyma. Because of volume averaging, conventional axial CT scans can fail to demonstrate a hyperattenuating sinus or an empty delta sign in the horizontal segment of the superior sagittal sinus or transverse sinus. The empty delta sign can disappear in chronic stages with enhancement of organized clot. The possibility of multiplanar reformations with CT venography is very helpful in detecting sinus and cortical venous thrombosis. CT venography with the integral display algorithm can provide excellent demonstration of filling defects in the superficial venous sinuses and cortical veins. Volume rendering display can be helpful to demonstrate collateral pathways in cortical vein thrombosis. The most reliable criterion with which to establish the diagnosis of cavernous sinus thrombosis is the presence of a large filling defect of non–fat attenuation with sinus expansion[13].

The results of this study showed that in the nonenhanced CT scans 12 patients (60%) had hemorrhagic infarctions, 6 patients (30%) had nonhemorrhagic infactions and 2 patients (10%) had normal brain parenchyma.The nonenhanced CT scans showed also that 7 patients (35%) had dense triangle sign & 2 patients (10%) had cord sign. Those results agree with the results of N. Khandelwal. *et al*[14] who reported that hemorrhagic infraction was seen in 60% of the cases, nonhemorrhagic infraction was seen in 13.3% of the cases, dense triangle sign was seen in 30% of the cases and cord sign was seen in 6.7% of the cases.

The results of this study showed also that the most frequently involved sinuses were, the superior sagital sinus (62%), the transverse sinus (40%), the sigmoid sinus (35%), the straight sinus (10%) and the Galen's vein (10%). Those results agree with the results reported by previous publications[1,14] who reported nearlt the same frequency of thrombosis of major sinuses.

CT venography is a rapid, readily available, and accurate technique for detecting cerebral venous thrombosis. CT venography provides a highly detailed depiction of the cerebral venous system, superior to that available with conventional TOF MR venography, and has at least equivalent accuracy for the detection of cerebral venous thrombosis. Drawbacks of CT venography include the difficulty of reconstructing maximum intensity projection (MIP) images from the source image data sets, a process that requires the subtraction of bone adjacent to the venous sinus; it is very difficult to subtract all of the adjacent bone without also subtracting part of the sinus. However, source images and multiplanar reformatted images can be displayed quickly for evaluation. Investigators in a recent study advocated the use of a matched mask bone elimination technique to improve the quality of MIP images reconstructed from CT venographic data[15].

In conclusion cerebral venous sinus thrombosis could be easily visualized and diagnosed by multidetector CT venography. MDCT venography is a fast, widely accessible, and cost-effective alternative to MR imaging, especially in the emergency setting, if MR is not feasible or in cases in which the results of MR are ambiguous and there is still a clinical suspicion of CVST. In patients with unenhanced CT findings suggestive of venous thrombosis, MDCT venography can be performed without delay to confirm the diagnosis and to start appropriate therapy immediately

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