Non-Enhanced CT Mimicking Contrast Enhanced CT - A Case Report on Polycythemia

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ABSTRACT

Diffuse hyperdense cerebral vasculature is sometimes encountered on non-enhanced computed tomography, and polycythemia is one of the conditions which appears the same. The current case report is of a case of 37-year-old female patient arrived with a complaint of feeling severe headache for the past 3 days which was insidious in onset, diffuse in nature and it did not respond to any medication. NECT brain study showed the hyperdense circle of Willis and cerebral venous sinuses. Contrast was not administered for computed tomography study of the brain. On blood investigations, the patient had raised hematocrit level (74%). The hyperdense vessel was due to raised hematocrit (Polycythemia Vera).

CASE REPORT

CASE REPORT

A 37-year-old female patient arrived with complaint of feeling severe headache for the past 3 days. It was gradual in onset, diffuse in nature and did not respond to any pain killers. She also gave a history of giddiness and blurring of vision. The patient reported no history of fever, nausea and/or vomiting, trauma, loss of consciousness or altered sensorium. The physical examination was unremarkable. Based on the above complaints, patient was further subjected for non-contrast CT brain.

NECT brain findings

NECT brain images revealed diffusely hyperdense vessels and dural sinuses. Hyperdensity noted in the vertebral arteries (Figure 1), Basilar artery (Figure 2), posterior inferior cerebellar artery (Figure 1), superior cerebellar artery (Figure 2), Circle of Willis branches involving Anterior cerebral artery (Figure 5), Middle cerebral artery (Figure 5), Posterior cerebral artery (Figure 5), Branches of internal carotid artery (Figure 2) Diffuse hyperdensity noted in the dural venous sinuses including transverse sinus (Figure 3), straight sinus (Figure 6) superior sagittal sinus (Figure 6) deep cerebral veins (Figure 6) , confluence of sinuses (Figure 4) and Falx cerebri (Figure 7) with attenuation values ranging from 69-74HU. There were no features suggestive of bleed, infarct, space-occupying lesion or edema.

Blood investigations

Patients' blood investigations showed raised hemoglobin (24gm/dl) with raised hematocrit (70%). WBC and platelet counts were within normal limit.

NCCT brain images were correlated with blood report; the diagnosis of Polycythemia was made.

DISCUSSION

Polycythemia is a condition wherein an abnormal elevation occurs in the circulation of red blood cell (RBC) mass. Often detected as an incidental finding, Polycythemia results in increased hemoglobin and hematocrit (Hematocrit is a ratio of volume of RBCs to the total volume of blood) [1].

It is apparent from the literature that studies on the characterization of the neurological conditions associated with polycythemia are not manifold. Polycythemia can cause diffuse hyperdensities of dural venous sinuses and vasculature of the brain including the Circle of Willis when hematocrit exceeds 60% [2]. A linear relationship exists between hemoglobin and the contrast of dural sinuses compared with gray matter, suggesting that increased density of cerebral vessels on NECT is a sign of high hemoglobin level [3]. Flowing blood at a hematocrit of 45% measures approximately 40HU. In normal individuals, hematocrit ranges from 42-52% and 37-47% in neonates. Thus, cerebral vasculature appears isodense or minimally hyperdense as the normal adult gray matter measures approximately 39HU [4]. World Health Organization criteria for diagnosing polycythemia vera, major criteria includes hemoglobin (HGB) greater than 16.5g/dL in women and 18.5 g/dL in men or other evidence of increased red cell volume such as hematocrit of at least 65% and presence of JAK2 V617F or other functionally similar mutations, such as JAK2exon 12 mutations. Minor criteria's like Bone marrow biopsy showing hypercellularity for age with trilineage growth with prominent erythroid, granulocytic, and megakaryocytic proliferation Serum erythropoietin level below the reference range for normal Endogenous erythroid colony formation in vitro. Diagnosis requires the presence of both major criteria and one minor criterion or the presence of the first major criterion together with two minor criteria [5,12].

Pathophysiology

The abnormal increase in number of circulating erythrocytes increases the risk of hyperviscosity, microcirculatory hypoperfusion, and multisystem organ dysfunction [5].

Etiology & Demographics:

Polycythemia can be divided into the following two categories;

- Primary Polycythemia: As a result of inherent problems with RBC production.
- Secondary Polycythemia: Due to response to factors or underlying conditions that promote RBC production.

Causes of Primary Polycythemia

Polycythemia Vera- Genetic mutation in the JAK2 gene, which increases the sensitivity of bone marrow cells to erythropoietin (EPO), results in increased RBC production.

Primary familial and congenital polycythemia (PFCP) in this there is a mutation in the EPOR gene and causes increased production of red blood cells in response to EPO [1].

Causes of Secondary Polycythemia

The main reasons for (higher) abnormal EPO may be chronic hypoxia, poor oxygen delivery due to abnormal RBC structure and tumors releasing inappropriately high amounts of EPO. Common conditions causing chronic hypoxia are a chronic obstructive pulmonary disease like COPD, emphysema, chronic bronchitis and other conditions like pulmonary hypertension, hypoventilation syndrome, congestive heart failure, obstructive sleep apnea, poor blood flow to the kidneys, living in high altitudes. Some of the erythropoietin secreting tumors are cerebellar hemangioblastoma, liver cancer (hepatocellular carcinoma), renal tumor (renal cell carcinoma), adrenal tumors, uterine cancer [1].

Clinical & Imaging findings:

Patients generally present with easy bruising, easy bleeding, bone and joint pain, headache, itching, post-bath pruritus, fatigue, dizziness, abdominal pain. Blood investigations are useful in diagnosing polycythemia. In polycythemia, the number of RBC, WBC (leukocytosis) and platelets (thrombocytosis) is abnormally higher than the normal. Bone marrow is sometimes necessary to examine blood cell production in the bone marrow and checking for the JAK2 gene in primary polycythemia, the EPO level is typically low, whereas, in EPO-secreting tumors, the level may be higher than normal [1].

On NECT brain there is increased radiographic attenuation of cerebral arteries, veins and dural sinuses (may mimic cerebral vein thrombosis) [7]. Other findings like Splenomegaly, organ infarcts, features of extramedullary hematopoiesis in spleen can be seen on X-ray, USG and CECT abdomen [7].

Treatment & Prognosis:

Therapeutic options in polycythemia vera are limited and no cure is available. The goal of current treatment is to prevent the occurrence of thrombosis/ vascular events and treatment for PV aim at targeting Hct <45%. Primary polycythemia is treated with low dose aspirin, phlebotomy, JAK 2 inhibitors. Treatment of secondary polycythemia depends on its cause. Supplemental oxygen can be provided for individuals with chronic hypoxia. Venesection, hydroxyurea, Myelosuppressive medications and Interferon are used. Anagrelide is used in secondary thrombocythaemia. Prognosis is variable [1,6,7,12].

Complications

Polycythemia can lead to complications such as splenic infarction, venous thrombosis, acute superior mesenteric venous thrombosis, dural venous sinus thrombosis, Budd-Chiari syndrome, cerebrovascular events and Myocardial infarction [6].

Differential Diagnosis:

Physiological Polycythemia

- Neonatal polycythemia
- Severe Dehydration

Unmyelinated Brain: Infants and young children often have higher hematocrits and relatively lower density of their unmyelinated brains. High-attenuation blood vessels and low-attenuation brain make all vascular structures (including dural sinuses and cortical veins) appear relatively hyperdense in contrast to brain matter [8].

Diffuse cerebral edema: The decrease in density of the cerebral hemispheres makes the dura and all the intracranial vessels both veins and arteries appear relatively hyperdense when compared with the low-density brain [8].

Subdural Hematoma In acute SDH, hemorrhage layers along the medial tentorium and straight sinus can cause hyperdensity [8].

Cerebral venous sinus thrombosis: There occurs selectively increased attenuation of dural venous sinuses. Both polycythemia and venous thrombosis present as the increase in CT attenuation of cerebral venous sinuses. Also, cerebral venous thrombosis is a known complication of polycythemia and hypercoagulable states and they may coexist. So it becomes necessary to differentiate between them [9,10]. Definite differentiation between the two can be done by MR venogram or CT venography [4].

Attenuation of more than 70HU is suggestive of venous sinus thrombosis and less than 70HU is suggestive of polycythemia [11].

TEACHING POINT

Hyperdensity of cerebral vasculature and venous sinuses may be associated with Polycythemia. Polycythemia may mimic as well as cause venous thrombosis, confounding non-enhanced computer tomography findings. One should meticulously rule out the cause of hyperdense vasculature by MR venogram, CT venography or catheter venography.

REFERENCES

1. Stuart BJ, Viera AJ. Polycythemia vera. American family physician. 2004 May 1;69(9).PMID:15152961.

2. Rastogi R. Computed tomography of the brain in polycythemia. The medical journal, Armed Forces India. 2008 Oct;64(4):377. PMID: 27688585.

3. Ben, D. Salem, et al. Spontaneous hyperdense intracranial vessels seen on CT scan in polycythemia cases. Journal de radiology. 2003 May;84(5):605-8. PMID: 13677826.

4. Grossman CB. Physical Principles of Computed Tomography and Magnetic Resonance Imaging of the Head and Spine. 2nd edition. Williams&Wilkins. 1996:10-58. ISBN: 0397551568.

5. Remon JI, Raghavan A, Maheshwari A. Polycythemia in the Newborn. NeoReviews. 2011 Jan 1;12(1):e20-8.PMID:12223385.

6. Healy JF, Nichols C. Polycythemia mimicking venous sinus thrombosis. AJNR. American journal of neuroradiology. 2002 Sep 1;23 (8): 1402-3.PMID:12223385.

7. Brandt L, Anderson H. Survival, and risk of leukemia in polycythemia vera and essential thrombocythemia treated with oral radiophosphorus: are safer drugs available? (1995) European journal of hematology. 54 (1): 21-6. PMID: 7859872.

8. Osborn AG. Diagnostic Neuroradiology. 2nd Indian reprint.Mosby, 2007;158-388 ISBN:0721629059.

9. Gayathri S, Prasad A, Sachdeva N, Baruah BP, Aggarwal S. Unique features of polycythemia observed on plain noncontrast CT scan of the head. Journal of pediatric neurosciences. 2010 Jan;5(1):27. PMID: 21042503.

10. Bhoil R. Peculiar NCCT Brain Picture in Polycythemia. Journal of Postgraduate Medicine, Education, and Research. 2014 Oct 1;48(4):197. DOI: 10.5005/jp-journals-10028-1130.

11. Black DF, Rad AE, Gray LA, Campeau NG, Kallmes DF. Cerebral venous sinus density on noncontrast CT correlates with hematocrit. American Journal of Neuroradiology. 2011 Aug 1;32(7):1354-7.PMID:21566009.

12. Griesshammer M, Gisslinger H, Mesa R. Current and future treatment options for polycythemia vera. Annals of hematology. 2015 Jun 1;94(6):901-10. PMID: 25832853

13. Corse AK, Kurtis H. Ischemic Stroke Caused by Secondary Polycythemia and Incidentally-Found Renal Cell Carcinoma: A Case Report. The American journal of case reports. 2018;19:638. PMID: 29861497

14. Afzalimoghaddam M, Edalatifard M, Farahmand S, Bagheri-Hariri S, Mirfazaelian H. Imaging suggestive,but symptoms atypical.2017:25-26. PMID: 28084980

15. Lim BK. Clinics in diagnostic imaging (146). Singapore medical journal. 2013 May 1;54(5):289-91. PMID: 23716157

16. Cheng S, Chng SM, Singh R. Cerebral venous infarction during a high altitude expedition. Singapore Med J. 2009 Aug 1;50(8):e306-8. PMID: 19710966

FIGURES

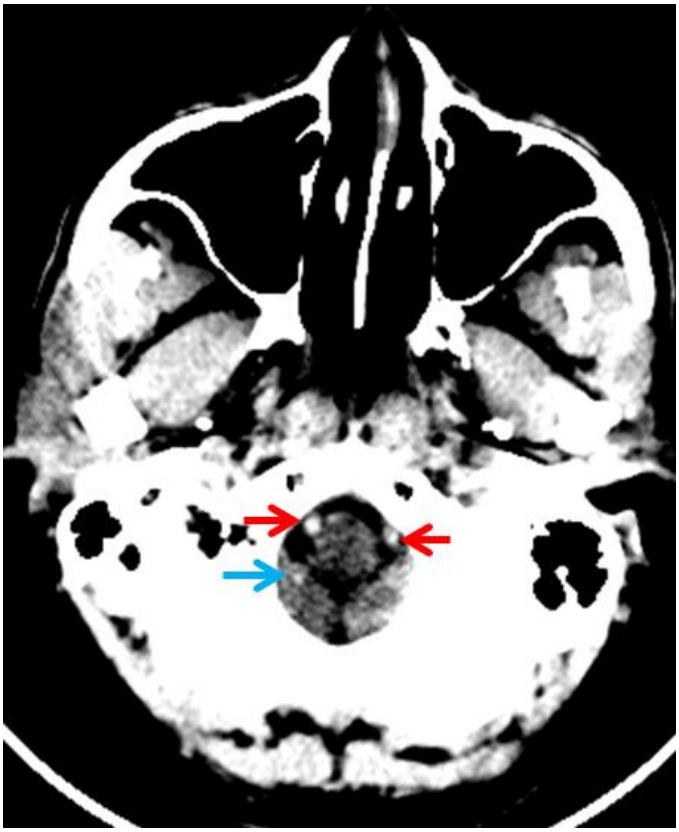

Figure 1: 37-year-old female with Polycythemia
Findings: NCCT brain axial view showing hyperdense bilateral vertebral arteries (Red arrow, HU value 68-74), posterior inferior cerebellar artery (blue arrow).
Technique: Axial Non-enhanced CT scan (Multislice, 64-detector) of the Brain (140 kV, 100 mA).

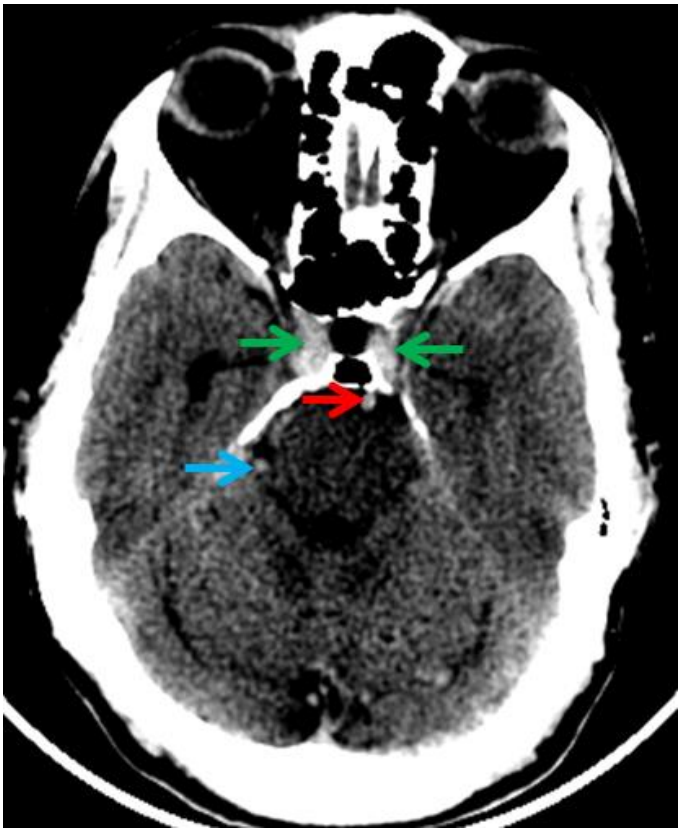

Figure 2: 37-year-old female with Polycythemia
Findings: NCCT brain axial view showing hyperdense basilar artery (Red arrow, HU value 65-69) superior cerebellar artery (blue arrow) and C4 cavernous internal carotid artery (green arrows).
Technique: Axial Non-enhanced CT scan (Multislice, 64-detector) of the Brain (140 kV, 100 mA).

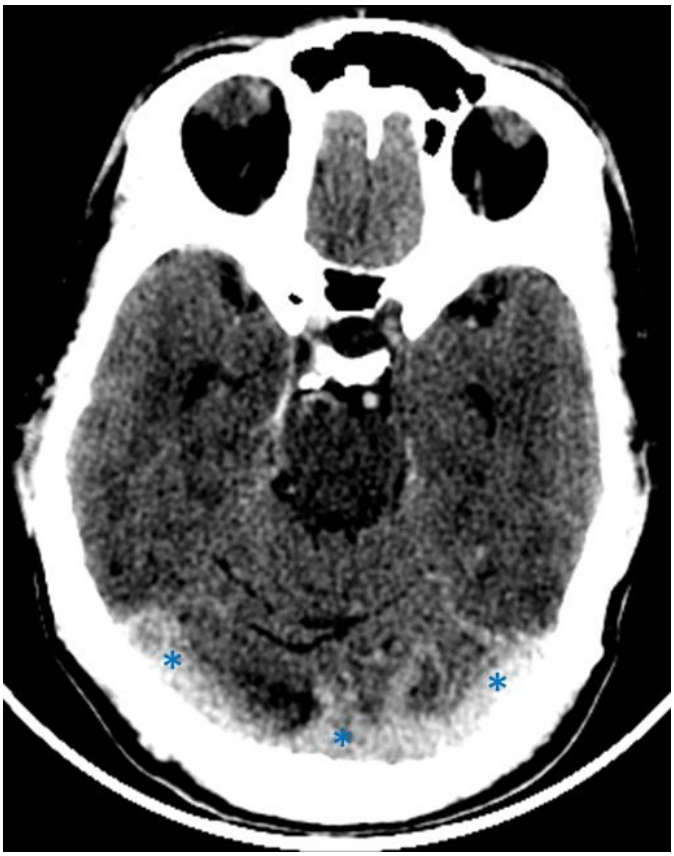

Figure 3 (left): 37-year-old female with Polycythemia
Findings: NCCT brain axial view showing hyperdense transverse sinus (blue asterisks, HU value 63-68).
Technique: Axial Non-enhanced CT scan (Multislice, 64-detector) of the Brain (140 kV, 100 mA).

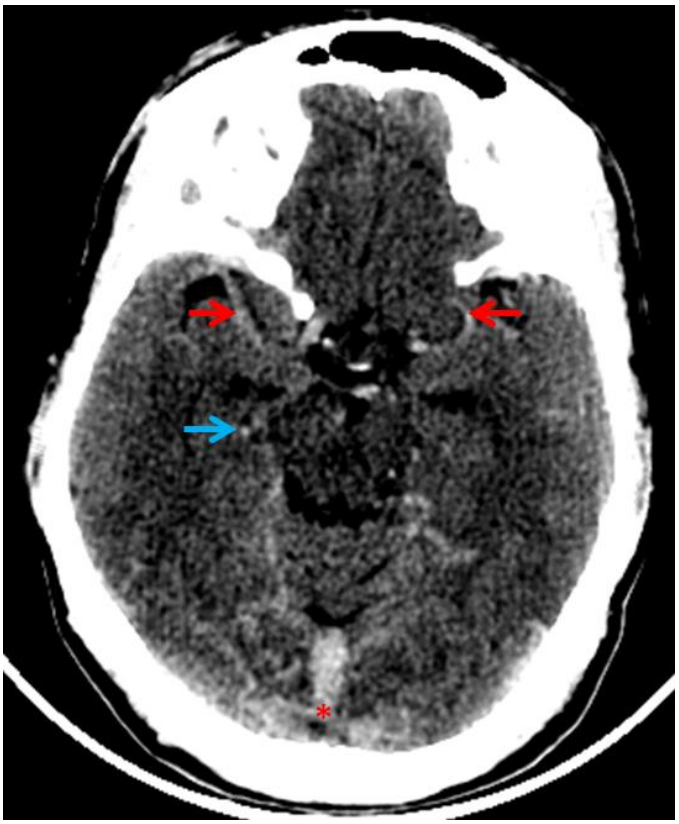

Figure 4: 37-year-old female with Polycythemia
Findings: NCCT brain axial view showing hyperdensity in confluence of sinuses (red asterisk), Posterior cerebral artery (blue arrow), Middle cerebral artery (red arrow, HU value 60-65).
Technique: Axial Non-enhanced CT scan (Multislice, 64-detector) of the Brain (140 kV, 100 mA).

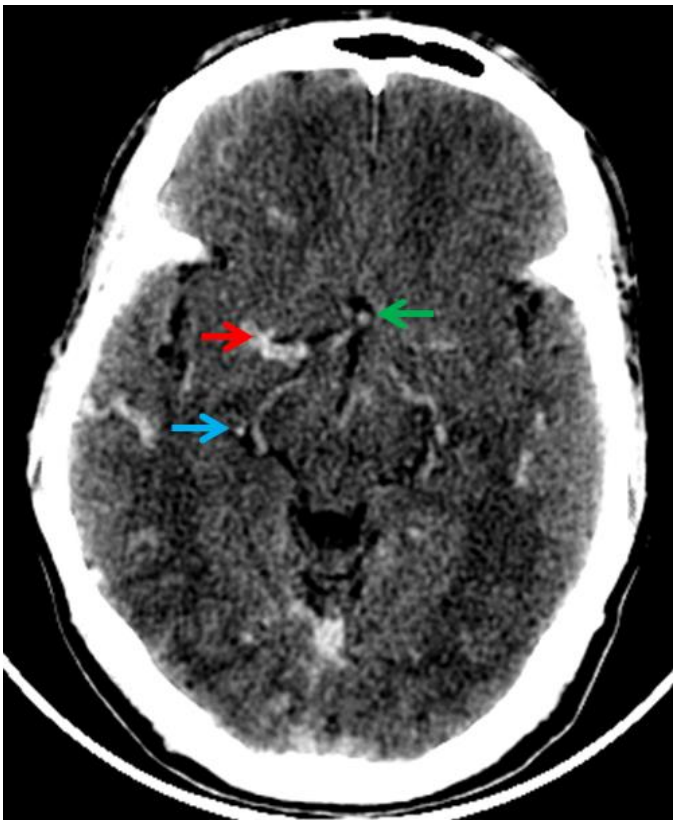

Figure 5: 37-year-old female with Polycythemia
Findings: NCCT brain axial view showing hyperdense Posterior cerebral artery (blue arrow), Middle cerebral artery (red arrow), Anterior cerebral artery (green arrow) with HU value 60-65.
Technique: Axial Non-enhanced CT scan (Multislice, 64-detector) of the Brain (140 kV, 100 mA).

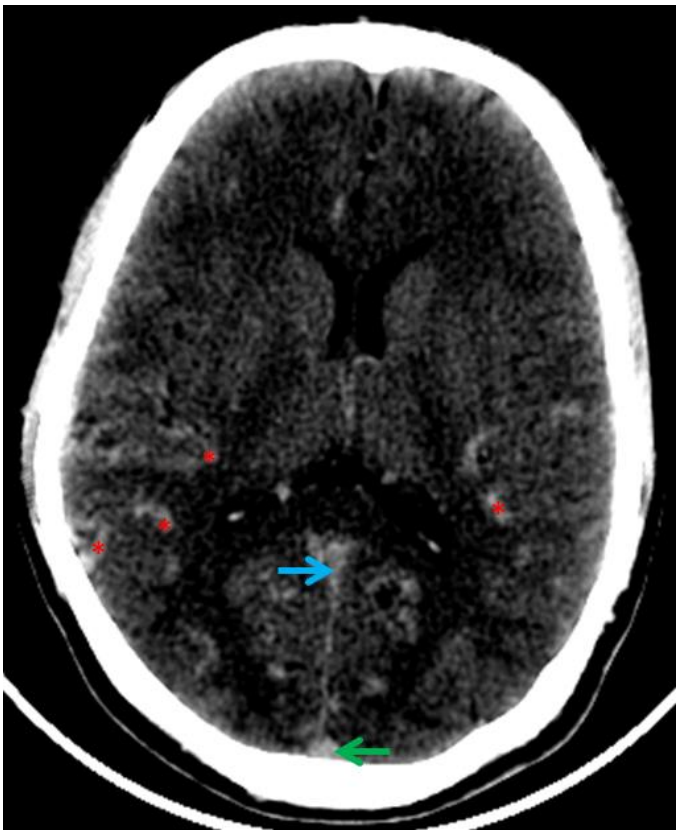

Figure 6 (left): 37-year-old female with Polycythemia
Findings: NCCT brain axial view showing hyperdense straight sinus (blue arrow) Straight sinus (green arrow), Deep cortical veins (red asterisks, HU value 58-65).
Technique: Axial Non-enhanced CT scan (Multislice, 64-detector) of the Brain (140 kV, 100 mA).

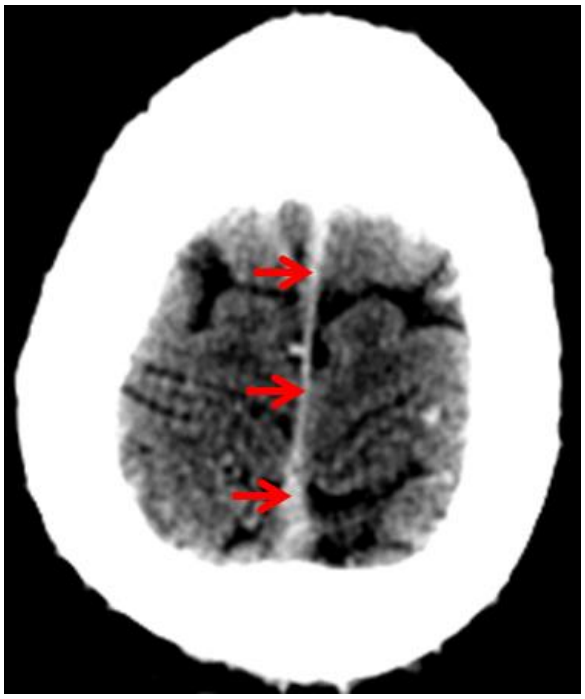

Figure 7 (left): 37-year-old female with Polycythemia
Findings: NCCT brain axial view showing hyperdense falx cerebri (red arrows, HU value 60-64).
Technique: Axial Non-enhanced CT scan (Multislice, 64-detector) of the Brain (140 kV, 100 mA).

Etiology	Primary familial and congenital polycythemia Secondary Causes chronic hypoxia
Incidence	Around 2-3 per 10,000 people.
Gender Ratio	Slightly greater male predilection.
Age Predilection	Older individuals
Risk Factors	✓ Familial and genetic predisposition; Chronic hypoxia; Living in high altitudes; ✓ Long-term cigarette smoking; Long-term exposure to carbon monoxide (tunnel workers, car garage attendants, residents of highly polluted cities)
Criteria for Diagnosis	**World Health Organization criteria for diagnosing polycythemia vera** Major criteria: Hgb >18.5 g/dL in men, >16.5 g/dL in women, or other evidence of increased red cell volume; Presence of JAK2 V617F or other functionally similar mutations, such as JAK2exon 12 mutations Minor criteria: Bone marrow biopsy showing hypercellularity for age with trilineage growth with prominent erythroid, granulocytic, and megakaryocytic proliferation; Serum erythropoietin level below the reference range for normal; Endogenous erythroid colony formation in vitro Diagnosis requires the presence of both major criteria and one minor criterion or the presence of the first major criterion together with two minor criteria.
Treatment	✓ Treatment of secondary polycythemia depends on its cause. ✓ Supplemental oxygen; Phlebotomy ✓ JAK 2 inhibitors; Myelosuppressive medications; Interferon; Aspirin; Anagrelide is used when secondary thrombocythaemia
Complications	✓ Cerebrovascular events; Splenic infarction; Myocardial infarction ✓ Venous thrombosis ➢ Acute superior mesenteric venous thrombosis ➢ Dural venous sinus thrombosis ➢ Budd-Chiari syndrome
Prognosis	Variable
Findings on Imaging	✓ Increased radiographic attenuation of cerebral arteries, veins and dural sinuses ✓ Splenomegaly ✓ Organ infarcts e.g. Splenic infarcts ✓ Features of extramedullary hematopoiesis in spleen

Table 1: Summary table of Polycythemia.

	General	NCCT
Polycythemia	• Increased red blood cell mass.	• Increased radiographic attenuation of cerebral arteries, veins and dural sinuses. • On CT venogram, there is no a filling defect in the veins and sinuses.
Neonatal Polycythemia	• Infants and young children often have higher hematocrit	• Relatively hyperdense brain vasculature.
Unmyelinated Brain	• In Infants and young children myelination of brain incomplete.	• High-attenuation blood vessels and low-attenuation brain make all vascular structure, dural sinuses and cortical veins seem relatively hyperdense
Diffuse Cerebral Edema	• A number of interconnected processes which result in abnormal shifts of water in various compartments of the brain parenchyma.	• Diffuse cerebral edema with decreased density of the cerebral hemispheres makes the dura and all the intracranial vessels both veins and arteries appear relatively hyperdense compared with the low-density brain. • Grey-white matter differentiation is maintained and the edema involves mainly white matter, extending in finger-like fashion. • Effacement of cerebral sulci, with or without midline shift.
Subdural Hematoma	• Collection of blood accumulating in the subdural space, the potential space between the dura and arachnoid mater of the meninges around the brain. • SDH can happen in any age-group. • It mainly due to head trauma.	• In acute SDH that layers along the medial tentorium and straight sinus can cause hyperdensity.
Cerebral Vein Thrombosis	• A subset of cerebral venous thrombosis involving the internal cerebral veins, often coexisting with cortical vein thrombosis or Dural venous sinus thrombosis, and with different clinical presentations relying on which segment is involved.	• On NECT shows non-specific findings. When not associated with venous hemorrhage or infarction it can be hard to make the diagnosis. • Potential findings include: dense clot sign, cortical edema, peripheral hemorrhage (cortical linear density or gyriform heterogeneous hemorrhage). • With contrast administration, especially with a CT venogram, then a filling defect in the veins and sinuses is sought.

Table 2: Differential diagnoses table for hyperdense vasculature of brain in non-contrast enhanced computer tomography.

ABBREVIATIONS

CT = Computer tomography
EPO = Erythropoietin hormone
HB = Hemoglobin
HCT = Hematocrit
HU = Hounsfield unit
MRV = Magnetic resonance venogram
NCCT/NECT = Non-contrast enhanced computer tomography
PFCP = Primary familial and congenital polycythemia
PV = Polycythemia Vera
RBC = Red blood cells
SDH = Subdural hematoma
WBC = White blood cells

KEYWORDS

Hyperdense cerebral vasculature; Non-Contrast Computed Tomography; Polycythaemia; Increased hematocrit; MR venogram; CT venography