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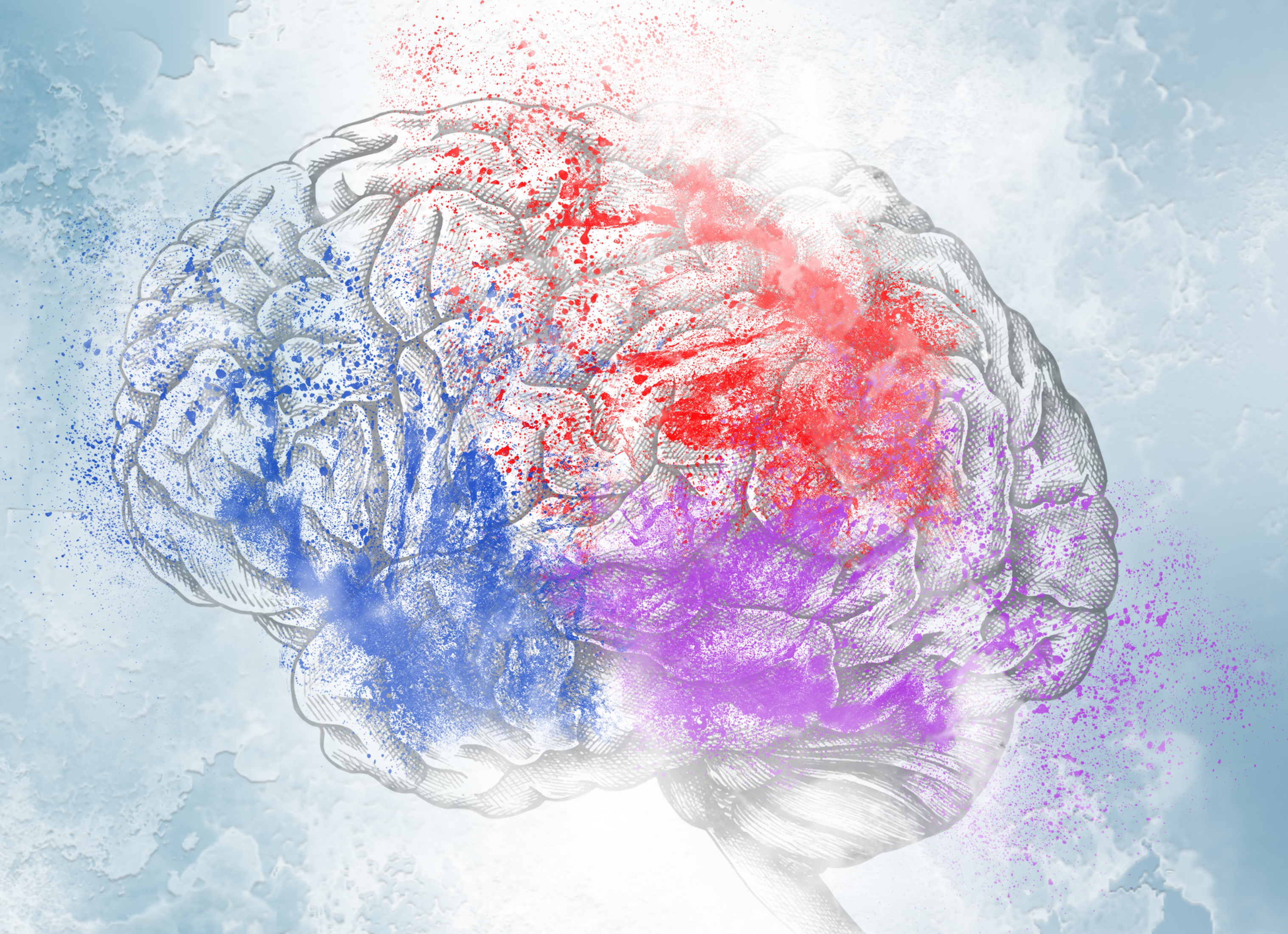

Collateral score on CT angiography in patients with acute ischemic stroke: a retrospective study | Embolization of anterior cranial fossa dural arteriovenous fistula | Evaluation of the clot burden score (CBS) for acute ischemic stroke (AIS) in intent-to-treat patients | Value of cone beam computed tomography to evaluate complication of intracranial haemorrhage in endovascular treatment (EVT): a case report.

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COLLATERAL SCORE ON CT ANGIOGRAPHY IN PATIENTS WITH ACUTE ISCHEMIC STROKE: A RETROSPECTIVE STUDY

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ABSTRACT

Objective: Clinically assessing the status of cerebral collaterals is thought to provide invaluable diagnostic and prognostic data in managing acute ischemic stroke (AIS) patients. In this study we present a report, based on commonly used collateral grading system, assessing the correlation between the collateral status seen on CT angiography and patients' functional outcome at Day 90 in our institution.

Method: Patients presenting to the Emergency Department within 6 hours of onset of stroke from January 2010 until December 2014 were chosen for the study. CT angiography source images were retrospectively reviewed and given a "collateral score" (CS) by a radiologist who was blinded to the patient's clinical information on presentation, as well as the clinical outcomes at 90 days. Patients' mRS score at 90 days was obtained retrospectively and compared against the "collateral score".

Results: 87 patients were enrolled into this study, of which 60 (69%) were male and 27 (31%) were female with a mean age of 60.3 years. In this study, 56 (64.4%) patients had a collateral score (CS) ≥ 2 and 31 (35.6%) patients had a CS < 2. Out of 56 patients who had a CS ≥ 2, 51 of them (91%) had good clinical outcome with a mRS ≤ 2. All the patients who had CS < 2 showed poor clinical outcome with a mRS > 2. The collateral score predicts accurately the clinical outcome with an area under the curve (ROC) of 0.75 (95% CI, 0.675-0.871, P=0.001). There is significant Spearman correlation between CS and the clinical outcome at Day 90, in patients with AIS during CTA analysis.

Conclusion: Our data supports the potential use of CS analysis in predicting clinical outcome of patients with AIS. Nevertheless, further study on a larger scale is strongly suggested to verify the reliability and reproducibility of CS assessment in CTA analysis prior to reperfusion in AIS patients.

Keywords: CTA brain, collateral score, clinical outcome, acute ischemic stroke, modified Rankin scale

1. INTRODUCTION

Cerebral collateral circulation is a vital alternative for temporary restoration of blood flow to ischemic areas due to obstruction within the principal arterial vessels supplying the brain. Collaterals are recruited primarily because of the restriction of blood flow as seen in acute ischemic stroke (AIS)[1]. An effective intrinsic reperfusion to the ischemic area is achieved by having an overall net flow between residual anterograde flow across the obstructive lesion and the circumventing contra-flow of blood around the lesion via collateral routes. The three major collateral pathways within the cerebrum that could potentially be recruited during arterial insufficiency events are the Circle of Willis, leptomeningeal collaterals, and extracranial–intracranial anastomosis[2].

Different imaging modalities have been employed to assess cerebral collateral flow in patients with ischemic stroke, namely digital subtraction angiography (DSA), computed tomography angiography (CTA) and magnetic resonance angiography (MRA)[3,4]. The degrees of utilization amongst these modalities, however, are varied. Although conventional DSA remains to be the most effective method to measure the degree of collateral extension and number, CTA is still considerably more favorable for grading collateral flow in a larger patient population, and has demonstrated good inter-observer reliability and correlation with patients' clinical outcome[5]. As any other technological innovation, the availability of advanced imaging modalities has increased, and is becoming cheaper and more accessible, as time goes by. CTA is frequently performed and supersedes conventional angiography for the assessment of patients with acute ischemic stroke in many hospitals, as CTA is more widely available and provides a rapid assessment of vascular anatomy and site of occlusion[6].

Clinically gauging the status of these cerebral collaterals is thought to provide invaluable diagnostic and prognostic data, in managing acute ischemic stroke patients. It has been considered as the only radiological predictor of clinical outcome in AIS despite its simplistic binary categorization[7]. According to Menon BK et all, a higher collateral score correlates with grade 2 or lower grading in modified Rankin Scale (mRS) 3 months after a stroke[8]. In the same study, good clinical outcomes were seen in 52% of patients, with good regional leptomeningeal collateral (rLMC) score (17-20), 34 % with medium rLMC score (11-16), and 7% with poor rLMC score (0-10)[8].

In this article, we present a report, based on a commonly used collateral grading system[6], assessing the correlation between the collateral status seen on CT angiography and patients' functional outcome at Day 90, in our institution. We also present evidence showing the reliability of the collateral score in predicting favorable clinical outcome in acute ischemic stroke patients.

2. SUBJECTS AND METHODS

Patients: This 5-year, single-center, retrospective study was performed at one of the teaching hospitals in Kuala Lumpur, from January 2010 to December 2014. Patients presenting to the Emergency Department of the said teaching hospital within 6 hours of onset of stroke were chosen for the study. Patients with intracranial bleed, or upon radiological assessment revealed very poor image quality, incomplete coverage, or poor contrast opacification of the vessels on the normal side were excluded from this study.

The patients' collateral circulation from the CTA source images upon admission were retrospectively reviewed by a radiologist with 5-years of experience, and were scored based on locally developed guidelines. Patients' mRS ratings at Day 90 post-admission from acute ischemic stroke were gathered from their clinical case notes separately, and were compared against the "collateral scores" given. Patients' clinical information on presentation, as well as their mRS at Day 90 was withheld from the reviewing radiologist.

"Collateral score": The commonly used collateral grading system was used to predict tissue fate in the setting of acute ischemic stroke. This scoring system, termed "collateral score" (CS) consists of a grade of 0 to 3 (Table 1 & Figure 1). Grade 0 is defined as an absence of collateral vessels compared to the contralateral normal hemisphere. Grade 1 is defined as less than 50% of collateral vessels compared to the contralateral normal hemisphere. Grade 2 is defined as collaterals more than 50%, but less than 100% of collateral vessels compared to the contralateral normal hemisphere. Grade 3 is defined as those having 100% collateral vessels compared to the contralateral normal hemisphere.

Imaging analysis: Patients were scanned using a Siemens multi-section 64 detectors CT scanner. Non-contrast enhanced CT (NCCT) of the head with slice thickness of 5 mm followed by CTA with a helical scan technique were employed. The coverage for CTA brain was set to extend from the aortic arch, to the vertex of the skull with continuous axial sections.

CTA acquisition using bolus tracking was obtained after a single, 100 ml non-ionic intravenous bolus contrast media injection (Iopamiro) at 5 mls/sec via an 18G venous access cannulation at the antecubital fossa. Region of Interest (ROI) was placed at the ascending aorta. An image processing software designed for multiplanar reconstruction and volume rendering was used to reconstruct 2D multiplanar reconstruction images in axial, coronal and sagittal planes. The collateral scores were graded from these images.

Clinical assessment: Patients' clinical conditions at the 90th day after the onset of AIS, assessed by neurologists or neurology specialist trainees in the stroke clinic, were obtained from their clinical notes. The mRS scores, ranging from 0-6 were given. For the purpose of this report, the mRS scores were classified into two main groups: good functional outcome (scale of 0-2) and poor functional outcome (scale of 3-5; with 3 being partially dependent and 5 fully dependent).

3. RESULTS

A total of 87 patients who fulfilled all the inclusion and exclusion criteria were chosen for this study, of which 60 (69%) were male, and 27 (31%) were female (Figure 2). The mean age is 60.3 years, with the youngest being 35 years old and the oldest patient being 91 years old (Figure 3).

In this study, 56 (64.4%) patients had a CS $\geq$ 2 and 31 (35.6%) patients had a CS < 2 (Table 2), based on the blinded assessment carried out by the radiologist. 51 (91%) out of 56 patients who scored 2 or more on the CS showed a good clinical outcome, with mRS $\leq$ 2. Interestingly, all patients who had CS of less than 2 were reported to have poor clinical outcome, with a mRS > 2. The Spearman correlation analysis between the collateral score and modified Rankin scale showed a significant negative correlation (r = -0.877; p = 0.01; Table 3).

The collateral score (CS) has accurately predicted the clinical outcome of these patients, with an area under the Receiver-Operating Characteristic (ROC) curve of 0.77 (95.0% CI, 0.675-0.871; p=0.001) (Figure 4). From this analysis, the calculated specificity (true positive rate) is 72.2%, and its false positive rate 26.1%, with 1.5 as its cut off point.

4. DISCUSSION

The current treatment strategy for acute stroke focuses on early recanalization to prevent patients from suffering irreversible neurological deficits due to an ischemic event of the affected brain region. However, the success of revascularization depends not only on the restoration of the primary arterial occlusion, but also on the presence of reperfusion at the distal vascular bed, supplied by the collateral vessels. Prior to recanalization, it is a widely held view that the degree of collateral flow should be evaluated to predict the final infarct volume and to determine the clinical outcome of AIS patients.

Based on our results, we found a strong negative correlation between these two parameters; the higher the CS given at presentation, the lower the mRS obtained approximately 3 months after. In other words, the more collateral vessels present at the ischemic area within 6 hours of symptom presentation corresponds to a better functional outcome in patients with acute ischemic stroke at the end of the 90th day from the onset of stroke. Our findings broadly support, and are consistent with, the work of other studies that look into the correlation of collateral assessment in predicting patients' functional outcomes with an acute ischemic stroke, albeit of the varying imaging methods and grading systems [2, 5-6, 8-11]. These results also beg a further question; as to whether it is about time for collateral vessels assessment to be incorporated into stroke management guidelines and algorithm, given the benefits it has in providing diagnostic value, as well as prognostication, for the clinicians.

In a more recent study conducted by[12], the collateral flow has been shown to play a more substantial role in infarct growth and penumbral salvage as opposed to the time of onset of stroke symptoms. Hence, the "collateral clock" should be considered and prioritized as one of the key factors to a successful reperfusion, which is objectively made possible with collateral assessment grading, as opposed to the the 6-hour window period requirement in re-establishing the arterial flow. Furthermore, latest evidence from the DAWN Trial study has advocated the extension of the window period for reperfusion for acute stroke of up to 24 hours with endovascular thrombectomy for patients with clinical-infarct mismatch[13].

Collateral vessel assessment is only made possible with the availability of advanced imaging tools, such as CTA, a non-invasive diagnostic tool, which is widely available in many secondary care hospitals. It provides a rapid assessment of the vascular anatomy and the site of occlusion in AIS. In comparison to MRA, CTA has a faster scanning time and allows more accurate morphological assessment of the vascular anatomy, which further facilitates the decision for interventional therapy, and prognostication[8]. A recent monograph has also shown that CTA collaterals and CT perfusion can predict similar tissue sustenance[14].

Other than providing physicians with insights on the prognosis of AIS patients, the assessment of CS via CTA imaging may be a practical instrument for decision-making in providing the appropriate treatment, i.e. intravenous thrombolysis versus endovascular thrombectomy. The National Institutes of Health Stroke Scale (NIHSS) alone is insufficient to predict the probability of ischemic or hemorrhagic stroke, let alone in deciding a comprehensive treatment strategy for AIS patients. The findings of the CS could very well be, and serve as a useful diagnostic tool in the clinical setting of AIS. Further work is required to look at the usefulness of collateral grading towards the decision-making process, in terms of the recanalization treatment approach. We also propose a larger prospective study in the future to verify the reliability and reproducibility of the CS assessment on patients' outcome.

5. CONCLUSION

This study has demonstrated a significant correlation between the CS and clinical outcome at the 90th day, in patients with AIS during CTA analysis. Our data supports the potential of CS analysis from CTA to be used as a predictor for physicians to establish the prognosis of AIS. Nevertheless, further studies on a larger scale are strongly suggested to verify the reliability and reproducibility of the CS assessment in CTA analysis prior to reperfusion therapy in AIS patients.

Conflict of Interest
None declared.

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All the authors would like to thank Norazzila Omar and Dr Faizal Kamarol with the assistance in technical editing of the manuscript.

Figure Legends

Figure 1. Examples of CT brain images with corresponding collateral scoring written at the left upper corner.

Figure 2. ROC for collateral score (CS) prediction of clinical outcome. A threshold of >1.5 was found with an AUC of 0.77 (95.0% CI, 0.675-0.871, P=0.000).

Figure 3. Non-enhanced CT **(**NECT) brain (a) shows acute left MCA infarct and CTA brain (b) demonstrates a CS of 1 at left fronto-parietal region.

Figure 4. Non-enhanced CT **(**NECT) brain (c) shows acute right MCA infarct and CTA brain (d) demonstrates a CS of 3 at right fronto-parietal region.

Table 1. Collateral scoring system

Collateral Score	Collateral grading (compared to contralateral normal hemisphere)
0	Absent
1	0% < collateral < 50%
2	50% < collaterals<100
3	100%

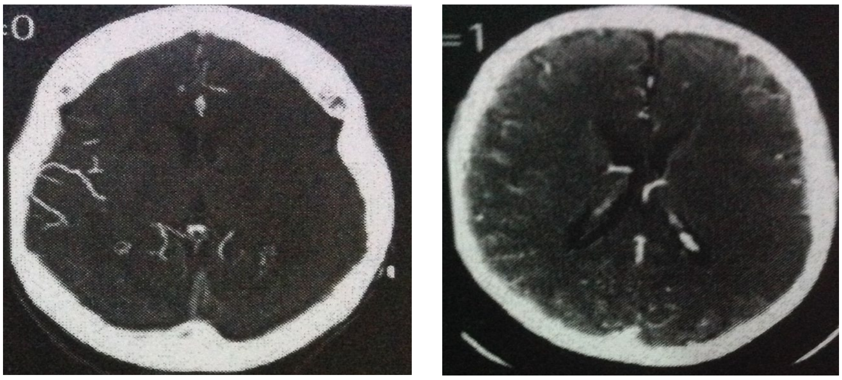
Table 2. *Patient clinical outcome dichotomized into good (mRS≤2) and poor outcome (mRS>2) at 90 days*

	Number of patients	**mRS ≤ 2**	**mRS >2**
Collateral score (CS), ≥2	56	51	5
Collateral score (CS), <2	31	0	31
Total	87	51	36

Table 3. *Spearman rank correlation of collateral score on CTA brain and modified rankin score (mRS)*

			Collateral score test person	**Modified Rankin score test person**
Spearman's rho	**Collateral score test person**	Correlation coefficient	1.000	-.874**
		Sig. (2-tailed)	-	.000
		N	87	87
	Modified rankin score test person	Correlation coefficient	-.874	1.000
		Sig. (2-tailed)	.000	-
		N	87	87

*** Correlation is significant at 0.01 level (2-tailed)*



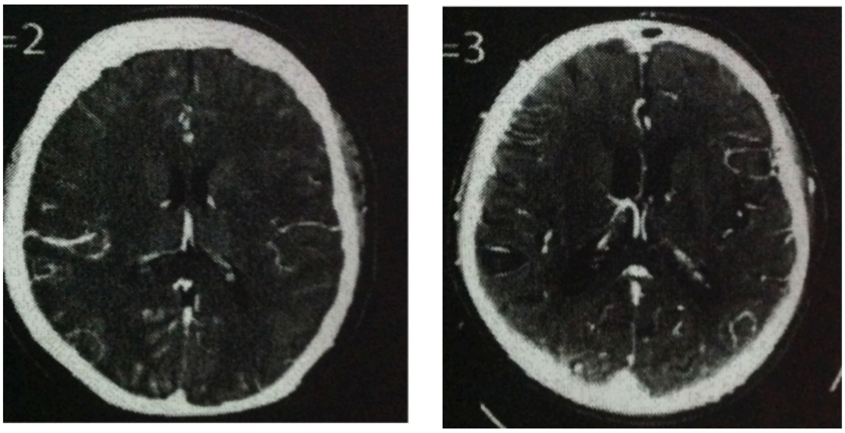


Figure 1. *Examples of CT brain images with corresponding collateral scoring written at the left upper corner.*

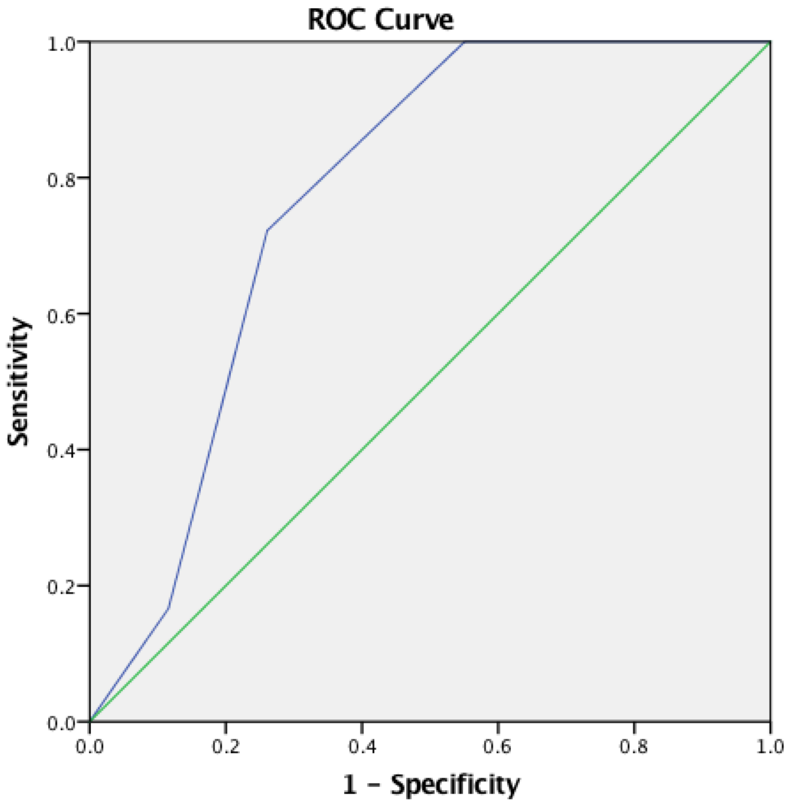


Figure 2. *ROC for collateral score (CS) prediction of clinical outcome. A threshold of >1.5 was found with an AUC of 0.77 (95.0% CI, 0.675-0.871, P=0.000).*

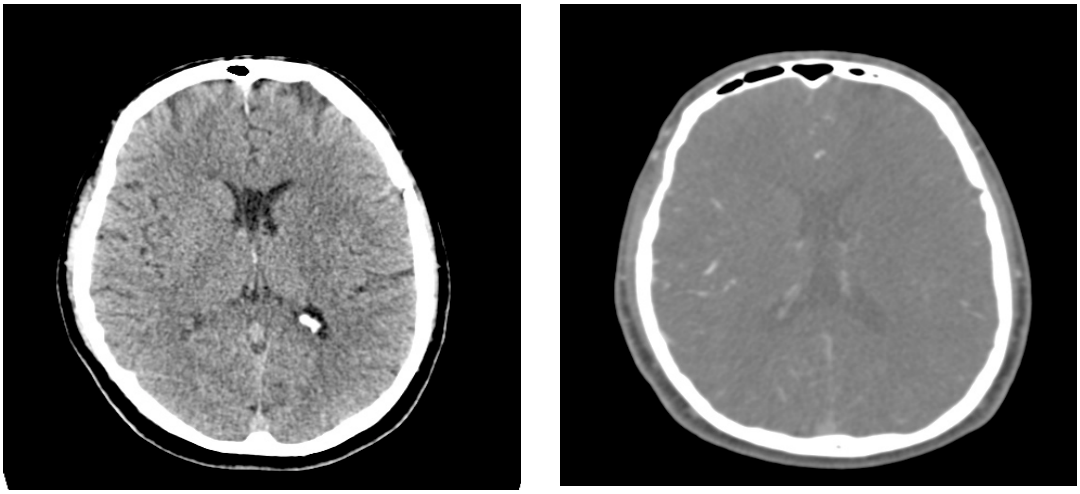


Figure 3. *NECT brain (a) shows acute left MCA infarct and CTA brain (b) demonstrates a CS of 1 at the left fronto-parietal region.*

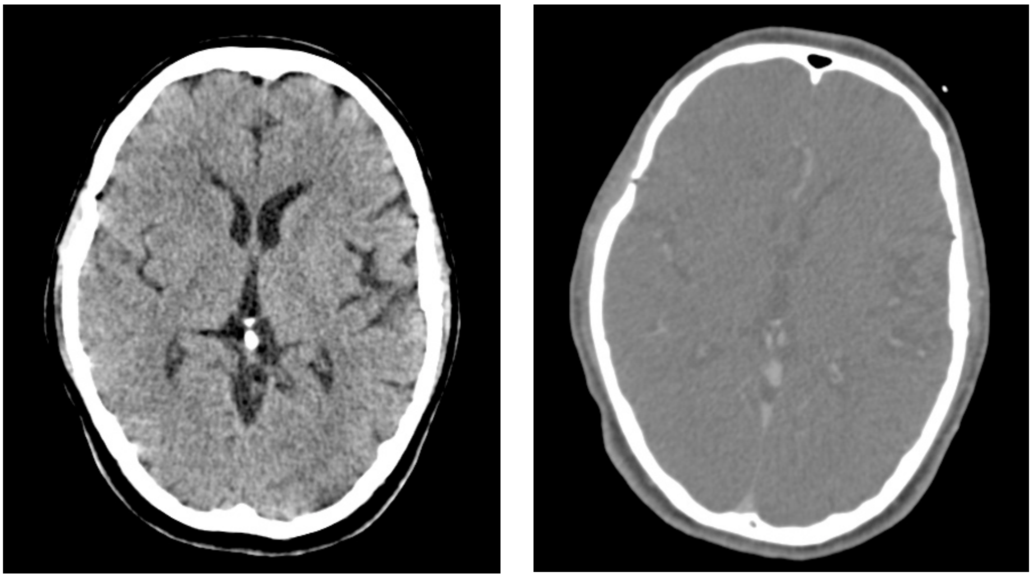


Figure 4. *NECT brain (c) shows acute right MCA infarct and CTA brain (d) demonstrates a CS of 3 at the right fronto-parietal region.*

REFERENCES

1. Liebeskind, David S. "Collateral Circulation." Stroke 34 (2003): 2279-2284.
2. I I Ismail, O Y Mansour, M E Reda, F M Talaat. "Assessment Of Collateral Pathways In Acute Ischemic Cerebrovascular Stroke Using A Mansour Grading Scale; A New Scale, A Pilot Study." The Internet Journal of Interventional Medicine 3.1 (2013).
3. Seena Dehkharghani, Jalal Andre. "Imaging Approaches to Stroke and Neurovascular Disease." Neurosurgery 80.5 (2017): 681–700.
4. Soke Miang Chng, Esben Thade Petersen , Ivan Zimine , Yih-Yian Sitoh , C.C. Tchoyoson Lim , and Xavier Golay. "Territorial Arterial Spin Labeling in the Assessment of Collateral Circulation Comparison With Digital Subtraction Angiography." Stroke 39.12 (2008): 3248–3254.
5. Johannes C. Gerber, Marketa Petrova, Pawel Krukowski, Matthias Kuhn, Andrij Abramyuk, Ulf Bodechtel, Imanuel Dzialowski, Kay Engellandt, Hagen Kitzler, Lars-Peder Pallesen, Hauke Schneider, Ruediger von Kummer, Volker Puetz & Jenn Linn. "Collateral state and the effect of endovascular reperfusion therapy on clinical outcome in ischemic stroke patients." Brain and Behavior 6.9 (2016).
6. I.Y.L. Tan, A.M. Demchuk, J. Hopyan, L. Zhang, D. Gladstone, K. Wong, M. Martin, S.P. Symons, A.J. Fox and R.I. Aviv. "CT Angiography Clot Burden Score and Collateral Score: Correlation with Clinical and Radiologic Outcomes in Acute Middle Cerebral Artery

Infarct." American Journal of Neuroradiology 30.3 (2009): 525-531.
7. Kucinski T, Koch C, Eckert B, Becker V, Krömer H, Heesen C, Grzyska U, Freitag HJ, Röther J, Zeumer H. "Collateral circulation is an independent radiological predictor of outcome after thrombolysis in acute ischaemic stroke." Neuroradiology 45.1 (2003): 11-8.
8. Menon BK, Smith EE, Modi J, Patel SK, Bhatia R, Watson TW, Hill MD, Demchuk AM, Goyal M. "Regional leptomeningeal score on CT angiography predicts clinical and imaging outcomes in patients with acute anterior circulation occlusions." American Journal of Neuroradiology 32.9 (2011): 1640-1645.
9. Singer OC, Berkefeld J, Nolte CH, Bohner G, Haring HP, Trenkler J, Gröschel K, Müller-Forell W, Niederkorn K, Deutschmann H, Neumann-Haefelin T, Hohmann C, Bussmeyer M, Mpotsaris A, Stoll A, Bormann A, Brenck J, Schlamann MU, Jander S, Turowski B, Petzol. "Mechanical recanalization in basilar artery occlusion: the ENDOSTROKE study." Annals of Neurology 77.3 (2015): 415-424.
10. Elijovich L, Goyal N, Mainali S, Hoit D, Arthur AS, Whitehead M, Choudhri AF. "CTA collateral score predicts infarct volume and clinical outcome after endovascular therapy for acute ischemic stroke: a retrospective chart review." Journal of NeuroInterventional Surgery 8 (2016): 559-562.
11. Ferdinand Miteff, Christopher R. Levi, Grant A. Bateman, Neil Spratt, Patrick McElduff and Mark W. Parsons. "The independent predictive utility of computed tomography angiographic collateral status in acute ischaemic stroke." Brain 132 (2009): 2231–2238.
12. Achala Vagal, Richard Aviv, Heidi Sucharew, Mahati Reddy, Qinghua Hou, Patrik Michel, Tudor Jovin, Thomas Tomsick, Max Wintermark, and Pooja Khatri. "Collateral Clock Is More Important Than Time Clock for Tissue Fate; A Natural History Study of Acute Ischemic Strokes." Stroke 49 (2018): 2102–2107.
13. Raul G. Nogueira, Ashutosh P. Jadhav, Diogo C. Haussen, Alain Bonafe, Ronald F. Budzik, Parita Bhuva, Dileep R. Yavagal, Marc Ribo, Christophe Cognard, Ricardo A. Hanel, Cathy A. Sila, Ameer E. Hassan, Monica Millan, Elad I. Levy et al. "Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct." The New England Journal of Medicine 378 (2018): 11-21.
14. Tan JC, Dillon WP, Liu S, Adler F, Smith WS, and Wintermark M. "Systematic comparison of perfusion-CT and CT-angiography in acute stroke patients." Annals of Neurology 61.6 (2007): 533-543

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EMBOLIZATION OF ANTERIOR CRANIAL FOSSA DURAL ARTERIOVENOUS FISTULA

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ABSTRACT
Dural arteriovenous fistulas (DAVFs) are abnormal connections between branches of the intracranial arteries and dural veins or sinuses. Advancements in the technique of endovascular embolization has made it the treatment of choice for DAVFs. The goal of treatment is to completely occlude the fistula orifice while maintaining the normal cerebral venous drainage. Depending on the site of the DAVF, endovascular treatment has its own challenges to the performing physician. In this case report, we will discuss complex anterior cranial fossa DAVFs, treatment approaches, and complications of the treatment.

Keywords: Anterior cranial fossa, Dural arteriovenous fistula, endovascular embolization

1. INTRODUCTION

Dural arteriovenous fistulas (DAVFs) are rare vascular abnormalities, which involve abnormal connections between branches of the intracranial arteries and dural veins or sinuses[1]. The exact etiology of DAVFs is unknown. A common predisposing factor for DAVFs appears to be venous sinus thrombosis[1]. DAVFs account for 10-15% of all intracranial arteriovenous malformations.

Although DAVFs can occur anywhere in the dura mater covering the brain, they occur most frequently in the cavernous and transverse-sigmoid sinuses. Patients may be asymptomatic or present with symptoms ranging from mild to severe, which include fatal hemorrhage. The venous drainage pattern of dural AVFs is the best predictive factor of severity and possible complications. Several classifications have been developed to stratify the risks of DAVFs. Both the Cognard and Borden classifications are the most widely used for this purpose[2].

2. CASE REPORT

A 52-year-old lady presented with sudden onset of unconsciousness while exercising. She was previously well, with no underlying co-morbidities. Upon arrival at the hospital, the Glasgow Coma Scale (GCS) was 3/15, the pupils were unequal and sluggish. Urgent non-contrasted CT brain was immediately performed which revealed a right frontal lobe intraparenchymal hemorrhage with associated right parietal subdural hemorrhage and midline shift [Figure 1].

The patient was immediately referred to the neurosurgery team. She underwent right decompressive craniectomy and evacuation of the clot. CT angiography of the brain was subsequently performed, showing dilated and tortuous vessels at the right parasagittal (frontal) region, which is continuous with the anterior part of the superior sagittal sinus. There was early opacification of the superior sagittal sinus in the arterial phase.

On diagnostic cerebral angiography, there was a dural arteriovenous sinus, with the feeding artery noted coming from the left ethmoidal branch of the ophthalmic artery. The dilated vessel is continuous with the anterior part of the superior sagittal sinus. Early opacification of the superior sagittal sinus was seen [Figures 2a, 2b]. After discussion with the neurosurgery team, we decided to proceed with an endovascular approach. Due to the complexity of the DAVF, we attempted trans-venous embolization via the internal jugular vein into the superior sagittal sinus. The procedure was complicated with spontaneous thrombosis at the fistula site.

The thrombosis caused spontaneous closure of the fistula at the dural side. Acute subdural haemorrhage was noted along the venous system. NCCT brain performed after the procedure showed well defined hyperdense areas, suggestive of thrombosis [Figure 3]. We proceeded with another attempt at embolization, via a trans-arterial approach. Cerebral angiography prior to second embolization showed pseudoaneurysm formation at the superior sagittal sinus [Figures 4a, 4b]. Selective cannulation of the branch of the feeder vessel with a microcatheter was done, followed by embolization with 45% N-butyl cyanoacrylate (NBCA). Complete occlusion of the fistula was achieved with no immediate complications [Figure 5]. Due to a prolonged intubation period, patient was put on tracheostomy tube and was discharged well with nursing care.

3. DISCUSSION & CONCLUSION

Anterior cranial fossa DAVFs account for about 2-3% of the total prevalence of DAVFs[2]. The specific etiology of anterior cranial fossa DAVFs is still unknown, but some cases have been reported being secondary to head trauma[3]. It is frequently associated with intracranial hemorrhage or other neurological symptoms; 12-15% presented with headache, 5-33% present with central nerve deficits, and 44-84% present with intracranial hemorrhage[2]. Angiography remains the gold standard for diagnosis and planning of therapy[1].

DAVFs located in the anterior cranial fossa usually drain through the retrograde leptomeningeal-cortical venous system only, which categorizes it into at least type III in the Cognard and Borden classifications. This results in a higher risk of intracranial hemorrhage. Complete cure is mandatory to prevent fatal complications.

Treatment options include radiation therapy, endovascular embolization, and surgical resection. There have been good results reported from the use of stereotactic radiotherapy for the treatment of DAVFs. However, it carries an unacceptable delay of about 1 - 3 years in curing DAVFs with cortical venous reflux and therefore is not recommended as a primary therapeutic measure[4]. Trans-arterial embolization (TAE) with N-butyl-2cyanoacrylate (NBCA), trans-venous embolization (TVE) with a cortical venous approach, as well as surgery have shown similar success rates for complete occlusion of anterior cranial fossa DAVFs[2]. In terms of potential risk and technical difficulty, TVE and TAE are at par. However, they appear to be potentially riskier and technically difficult compared to surgery, which in turn is more so than radiation therapy. Anterior cranial fossa DAVFs is almost always supplied by the bilateral ophthalmic artery, in which a trans-arterial approach is difficult and dangerous[2]. Among the branches of the ophthalmic artery is the retinal artery, which supplies the optic nerve. Slight mistakes in embolization of the ophthalmic artery can cause occlusion of the retinal artery with complete loss of vision in that eye.

Anterior cranial fossa DAVFs can safely be treated via a trans-venous approach. However, trans-venous approaches are often tortuous. The micro catheter should be advanced over the guidewire very gently to avoid spasm and rupture of the draining vein, or, eventually, a venous aneurysm[5]. In our case, we observed our patient developing spontaneous thrombosis and pseudoaneurysm formation after we attempted fistula closure via a trans-venous approach. Several studies have reported the complications associated with trans-venous embolization of DAVFs. A case series by Kim et al. found common complications post trans-venous embolization of DAVFs include cranial nerve palsy, venous perforation, and venous congestion[6]. Due to the difficulty of trans-venous access, and the risk of visual deficit by trans-arterial embolization, a surgical approach is relatively safe in treating anterior cranial fossa DAVFs by disconnecting the venous connection[7].

Embolic agents that are available include polyvinyl alcohol (PVA), N-butyl cyanoacrylate (NBCA) glue, platinum or stainless-steel coils, absolute alcohol, or Onyx. PVA is the easiest material to use, but it is a temporary agent. NBCA is more permanent compared to PVA, but is more difficult to administer with limited injection time due to polymerization. Onyx is a preferred embolic material because it is mechanically occlusive but non-adherent to the vessel wall. This allows prolonged feeder injection. However, the drawbacks include reflux proximally along the microcatheter, and slow injection with delayed penetration. It will also cause prolonged stay of the microcatheter in the ophthalmic artery, increasing the risk of thromboembolism and central retinal artery occlusion[5].

Figures

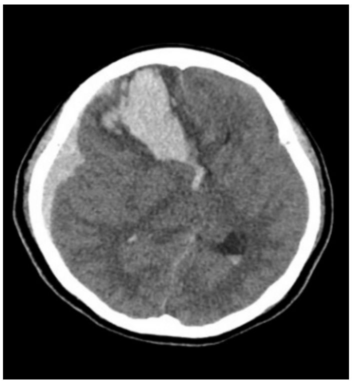

Figure 1. *Non-contrasted CT Brain showing right frontal lobe intraparenchymal hemorrhage, with right parietal subdural hemorrhage and midline shift.*

Figure 2a. *Antero-posterior projection of the left common carotid artery digital subtraction angiogram showing dural arteriovenous sinus with the feeding artery from the ethmoidal branch of the ophthalmic artery (arrow).*

Figure 2b. *Lateral projection of left common carotid artery digital subtraction angiogram showing dural arteriovenous sinus with the feeding artery from the ethmoidal branch of the ophthalmic artery (arrow).*

Figure 3*. Non-contrasted CT brain performed after the procedure. There is a bone defect at the right fronto-parieto-temporal region, in keeping with previous craniectomy changes. A ventriculo-peritoneal shunt tube is noted at the posterior horn of the left lateral ventricle. A well-defined hyperdense area at the right frontal lobe is seen, in keeping with thrombosis (arrow).*

***Figure 4a**. Cerebral angiogram prior to second embolization showing pseudoaneurysm formation at the superior sagittal sinus (arrow).*

***Figure 4b.** Cerebral angiogram prior to second embolization showing pseudoaneurysm formation at the superior sagittal sinus (arrow).*

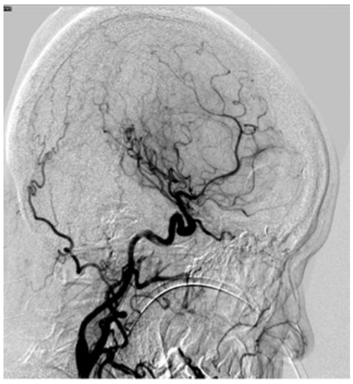

***Figure 5**. Cerebral angiogram post trans-arterial embolization showing complete occlusion of the DAVF*

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REFERENCES

1. Gupta A K, Periakaruppan A L. Intracranial dural arteriovenous fistulas: A Review. Indian J Radiol Imaging 2009; 19: 43-8.
2. Kiyosue H, Hori Y, Okahara M, Tanoue S, Sagara Y, Matsumoto S, et al. Treatment of intracranial dural arteriovenous fistulas: current strategies based on location and hemodynamics, and alternative techniques of transcatheter embolization. Radiographics 2004; 24(6): 1637-53.
3. Im SH, Oh CW, Han DH. Surgical management of an unruptured dural arteriovenous fistula of the anterior cranial fossa: natural history for 7 years. Surg Neurol 2004; 62(1): 72-5.
4. Lewis AI, Tomsick TA, Tew JM Jr. Management of tentorial dural arteriovenous malformations: transarterial embolization combined with stereotactic radiation or surgery. J Neurosurg 1994; 81(6): 851-9.
5. Rai SPV, Bele K, Reddy H. Endovascular Approach for Treatment of Frontal Dural Arteriovenous Fistula through the Ophthalmic Arteries using Glue: A Case Presentation with Review of Literature. Indian J Vasc Endovasc Surg 2015; 2: 125-9.
6. Kim DJ, Kim DI, Suh SH, Kim J, Lee S, Kim EY, et al. Results of transvenous embolization of cavernous dural arteriovenous fistula: a single-center experience with emphasis on complications and management. AJNR Am J Neuroradiol 2006; 27(10): 2078-82.
7. Choi HJ, Cho CW. Anterior cranial fossa dural arteriovenous fistulae presenting as subdural hematoma. J Korean Neurosurg Soc 2010 Feb; 47(2): 155–157.

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EVALUATION OF THE CLOT BURDEN SCORE (CBS) FOR ACUTE ISCHEMIC STROKE (AIS) IN INTENT-TO-TREAT PATIENTS

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ABSTRACT
Background : The clot burden score (CBS) is a scoring system used in acute ischemic stroke (AIS) to predict patient outcome and guide treatment decision. However, CBS is not routinely_practiced in many institutions. This study aimed to investigate the feasibility of CBS as a relevant predictor of good clinical outcome in AIS cases.
Methods: A retrospective data collection and review of AIS patients in a teaching hospital was done from June 2010 until June 2015. Patients were selected following the inclusion and exclusion criteria. These patients were followed up after 90 days of discharge. The Modified Rankin scale (mRS) was used to assess their outcome (functional status). Linear regression Spearman Rank correlation was performed between the CBS and mRS. The quality performance of the correlations was evaluated using Receiver operating characteristic (ROC) curves.
Results: A total of 89 patients with AIS were analysed, 67.4% (n=60) male and 32.6% (n=29) female. Twenty-nine (29) patients (33.7%) had a CBS ≥6, 6 patients (6.7%) had CBS <6, while 53 patients (59.6%) were deemed clot free. Ninety (90) days post insult, clinical assessment showed that 57 (67.6%) patients were functionally independent, 27 (30.3%) patients functionally dependent, and 5 (5.6%) patients were deceased. Data analysis reported a significant negative correlation (r= -0.611, p<0.001). ROC curves analysis showed an area under the curve of 0.81 at the cut-off point of 6.5. This showed that a CBS of more than 6 predicted a good mRS clinical outcome in AIS patients; with sensitivity of 98.2%, specificity of 53.1%, positive predictive value (PPV) of 76%, and negative predictive value (NPV) of 21%.
Conclusion: CBS is a useful additional variable for the management of AIS cases, and should be incorporated into the routine radiological reporting for acute ischemic stroke (AIS) cases.

Keywords: Acute ischemic stroke (AIS); Thrombus; Clot burden score (CBS); Modified Rankin scale (mRS); Receiver operating characteristics (ROC)

1. INTRODUCTION

Acute ischemic stroke (AIS) is defined as a rapid brain injury secondary to the disruption of blood flow to the brain tissue from a vascular luminal blockage[1]. It can be divided into two main types, i.e. thrombotic and embolic[2]. Thrombotic strokes occur due to thrombus that develops in the arteries that supply blood to the brain. On the other hand, an embolic stroke happens when a blood clot or plaque debris that developed elsewhere in the body travels and gets lodged into the cerebral vessels[3]. The occlusion deprives blood flow to the brain, i.e. impedes the oxygen and glucose supply to brain cells, which subsequently causes cellular necrosis and finally loss of normal bodily functions. Stroke, regardless of its origin, is one of the leading causes of death and the most frequent cause of disability in Malaysia[4]. Early revascularization to the ischemic brain regions has become a primary goal in the management of stroke patients, for minimizing brain injury[5].

In clinical practice, there are two types of reperfusion treatment approved for AIS, i.e. intravenous thrombolysis (IVT), and endovascular mechanical thrombectomy (MT)[6]. IVT is indicated for lysis of thrombus with the administration of intravenous recombinant tissue plasminogen activator (IV-rtPA). On the other hand, MT is an image guided minimally invasive procedure utilizing thrombectomy devices; such as stent retrievers and/or aspiration devices to trap and remove clots in the occluded artery[7]. Increasingly evidence shows greater recanalization rates with MT from 2015 onwards, especially cases with large vessel occlusions (LVOs) of the anterior circulation[8-10]. Nevertheless, the clot burden must be objectively quantified prior to initiating any form of reperfusion therapy. Thus, the stroke severity, and salvageability of the ischemic brain tissue can be determined, allowing appropriate treatment to be given promptly to patients[11].

The clot burden score (CBS) is a form of stroke assessment scale, which is developed to evaluate the degree of intracranial thrombus burden in patients with anterior circulation acute ischemic stroke[12]. It is a semi-quantitative based-scale, in which scores range from 0 to 10, based on the contrast opacification on computed tomography (CT) angiography[13]. A higher score implies the absence of a visible large vessel occlusion, while a lower score denotes visible clot; lower scores being worse. However, CBS scoring is not routinely practised in the clinical setting of AIS, and its value in the prediction of clinical outcome in stroke patients remains to be validated. Therefore, the present study aims to evaluate the reliability of CBS in predicting the clinical prognosis in intent-to-treat AIS patients.

2. SUBJECTS AND METHODS

Patients: This retrospective study was conducted on intent-to-treat AIS patients with CT Brain Perfusion (CTP) and subsequent CTA including MRA brain or cerebral angiography at the teaching hospital in Malaysia, between June 2010 and June 2015. Patients included in this study should not be diagnosed to have intracranial haemorrhage or mass effect during initial non-contrasted computed tomography (NCCT) brain examination.

Patients were excluded if they did not undergo brain CTA with either MRA or cerebral angiography assessment. Their demographic data, clinical presentation, and CBS scores were documented. Patients were grouped arbitrarily into CBS <6 and CBS≥6, i.e. high clot burden and low clot burden, respectively. The clinical outcome after 3 months (90 days) of initial presentation was assessed on follow up at the outpatient Neurology Clinic, in the teaching hospital.

Image acquisition: Computed Tomography (CT)

The CT imaging for stroke was performed using a 64-slice CT scanner (Sensation, Siemens). A plain CT brain, with contrasted CTA/CTP protocols were performed during the analysis. Vascular access was obtained via an 18G cannula at the antecubital fossa. Topogram was placed to include the C3 vertebral level cranially until the vertex; with acquisition parameters as follows: kV=80, mA=50, 0.2 s scan time, 0.6 mm slice thickness, 256 mm tomogram length, lateral view tube position. Non-contrasted brain plain sequential scan was proceeded from the base of skull area until the vertex with the following parameters: kV=120 mA=380, 51.05 mGy dose volumes, 1.0 s scan time, 2.4 mm slice thickness.

The images were reconstructed to image Kernel=H31s smooth with cerebrum windowing. Perfusion scan was performed at the level of the basal ganglia with 40 ml of low osmolar contrast media (LOCM Omnipaque 350 mg I/ml) with flow rate of 5 ml/s, kV= 80 mA=240, 434.70 mGy dose volumes, 40.15 s scan time, 5 s delay scan time after contrast insertion, 9.6 mm slice thickness, caudo-cranial image order at the area of the basal ganglia (axial view) using helical scanning. The images were then reconstructed to image Kernel=H31s smooth with cerebrum windowing. CTA brain proceeded with ROI placed at either internal carotid arteries (ICAs).

Image acquisition: Magnetic resonance imaging / angiography (MRI/MRA)

The MRI sequences included T2 FLAIR, GRE/SWI, DWI and MRA TOF. The acquisition parameters for **T2 FLAIR Coronal** sequence were as follows: TE=8100 ms, TE=107.0 ms, phase over sampling=0. **GRE** TE=26.0 ms, TR=800 ms, phase oversampling=0. **SWI** TR=27 ms, TE=20.0 ms phase oversampling=0, slice oversampling=12.5. **DWI/ADC** TE=97 ms, TR 3300 ms, phase over sampling=0. **MRA TOF** TR=25, TE=7.0.

Assessment of clot burden: The score for each individual patient was done retrospectively using a standard DICOM viewer software. The vascular images of the intracerebral CT angiography were viewed using OSIRIX Software approved by the Food and Drug Administration (FDA) for regular reporting. The scoring was done by a single reader, whom referred to an acknowledged CBS scheme, as well as correlated with the verified reports.

A score of 2 points is subtracted for thrombus found on CTA in the (a) supraclinoid ICA and each of the (b) proximal and (c) distal halves of the MCA trunk (Figure 1). A score of 1 point is subtracted for thrombus found in the (d) infraclinoid ICA and (e) A1 segment and for each affected M2 branch. A score of 10 indicates the absence of occlusion, while a score of 0 signified occlusion in all major intracranial anterior circulation arteries (Figure 2). In cases where the CT angiography/CBS was contradictory to that of the verified reports, the images were reviewed again by a staff neuro-radiologist.

Assessment of patient prognosis: The ability of patients to function independently was reassessed after 3 months of their initial presentation to UKMMC using the modified Rankin scale (mRS). The degree of disability was measured with a scale of 0 to 6. Functional independence were given scores of 0-2, while functional dependence with mRS scores of 3-6.

Statistical analysis: Data was reported using standard descriptive statistics, and analysed using IBM SPSS Statistical Software, version 22.0 (IBM Corp., USA). Receiver operating characteristic (ROC) curves analysis was performed on the CBS to evaluate its potential to serve as a tool to predict good clinical outcome in AIS patients. The area under the curve (AUC) was measured during the analysis. The correlation between the CBS and patient outcome, based on mRS, was analysed using the Spearman Rank correlation coefficient. Both the odds ratio (OR) and 95% CI were obtained. A p value of <0.05 was considered to be statistically significant.

3. RESULTS

Baseline data: A total of 105 patients who had AIS were identified during the study period. Among these, 89 were eligible to be enrolled into the study, in which the majority (60 patients, 67.4%) were male. A total of 23 patients had a median age of 61 ± 12.2 years old. The youngest and oldest patients were 28 and 86 years old, respectively. Forty-five of the included patients (50.6%) presented with unilateral left sided weakness, and 41 patients (46.1%) had unilateral weakness on the right side.

Clinical outcome: After 3 months of initial presentation, 57 patients (67.6%) were functionally independent, 27 patients (30.3%) were functionally dependent, and 5 patients (5.6%) were deceased. Fifty-three patients (59.6%) scored a CBS of 10. Six patients (6.7%) had a high clot burden (CBS <6), while 29 patients (33.7%) had a low clot burden (CBS ≥6).

Correlation between CBS and mRS (clinical outcome): ROC analysis demonstrated an AUC of 0.81 (95% CI, 0.70-0.92; P = .000). CBS of ≥6 predicted good clinical outcome with a sensitivity of 98.2%, specificity of 53.1%, positive predictive value (PPV) of 76%, and negative predictive value (NPV) of 21% (Figure 3). The odds ratio (OR) and likelihood ratio (LR) of the analysis were 11.7 (95% CI 3.4-40.0) and 19.1, respectively. The Spearman Rank correlation indicated a significant negative association between CBS and mRS (r= -0.611, p<0.001). Patients who presented with a high CBS (CBS>6) had a better prognosis or mRS, in comparison to that of those with CBS ≤6 (Figure 4).

4. DISCUSSION

Currently, the assessment of the clot burden in institutions in the country is done by a rough estimation of clot presence and extension with no standard evaluation followed. This method is prone to inter-reader variability; and reduces homogeneity of the group of patients treated, particularly when the evaluation of treatment outcome is of concern. The current assessment using CBS is fast and easy, however, is limited to the anterior circulation. This scoring system allots a total of 10 points for presence of contrast opacification in the major arteries on CTA; 2 points each are deducted for clot presence in the proximal M1, distal M1, and supraclinoid ICA, while 1 point each if it involves the infraclinoid ICA, M2 branches, and the A1 segment (Figure 1 and 2).

We have shown that in our clinical setting, a CBS <6 predicted a poor outcome, while those scoring 6 and above predicted a good outcome, using the mRS at 90 days. The analysis reported a smooth ROC curve with the AUC of 0.810 (95% CI 0.703-0.917), representing a good quality test. Our findings are similar to that of the study by Tan et al.[14], evaluating CBS and patient outcome. Since then, there have been a few studies, which corroborate these, findings[15-16]. Additionally, the utilization of CBS in routine radiological reporting may assist in identification of tandem lesions. Tsivgoulis et al., in their meta-analysis, found that those with a higher clot burden tend to also have tandem lesions, which render pre-treatment with IVT futile, making endovascular reperfusion with MT necessary[17].

Due to the retrospective nature of the study, our analysis is limited by heterogeneity in treatment, follow up technique, and time to treatment; common limitations in a clinically managed cohort of patients. A standardized algorithm in the management of future AIS cases may be invaluable to further validate the results of this study.

The decision on patient treatment pathway, and possible outcome may not only be based solely on CBS scores. Although it does seem ideal, proven to have a strong significant correlation, and is a good predictor of patient outcome, it is not without limitations. One study found that CTA regularly overestimates thrombus length[18]. The authors, in their study, showed that the distal end of the thrombus is overestimated due to non-opacification of the vessel and poor collateral supply. They proposed a role for delayed contrast enhanced CT to overcome this limitation. Additionally, the roles of NIHSS and ASPECT scores are relevant in our clinical setting, especially in situations where accessibility to CTA, MRA or cerebral angiography is limited.

5. CONCLUSION

The current study shows that CBS is a good predictor of patient outcome. It is a relatively easy and simple method in quantifying clot burden, apart from being systematic. This reduces heterogeneity in patient selection, assists in selection of treatment strategies, and prognosticates patient outcome; and should be incorporated in routine radiological reporting of AIS cases.

Figure

Figure 1*. An image of T-carotid with segmental values for CBS, adopted from Puetz et. al.[13]*

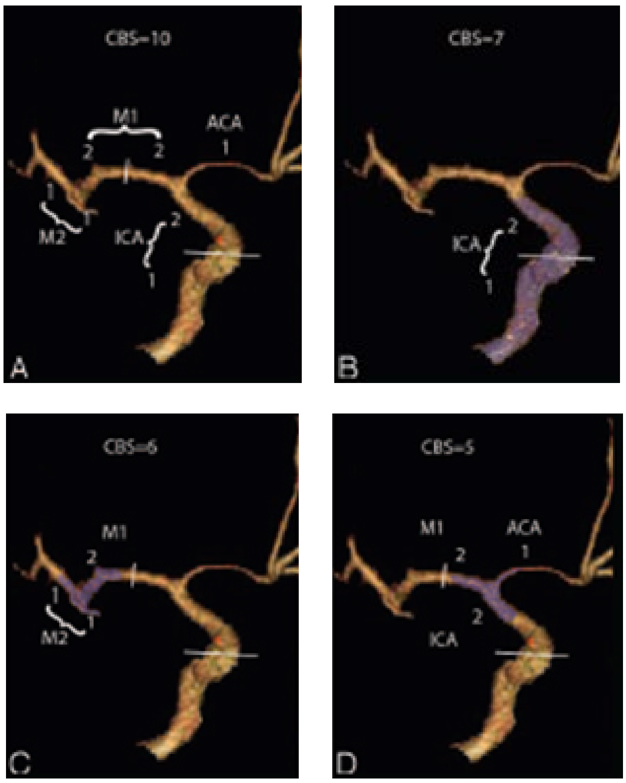

Figure 2. An example of substraction evalution of CBS, with presence of clot in the particular segments adopted from Tan et.al.[14]

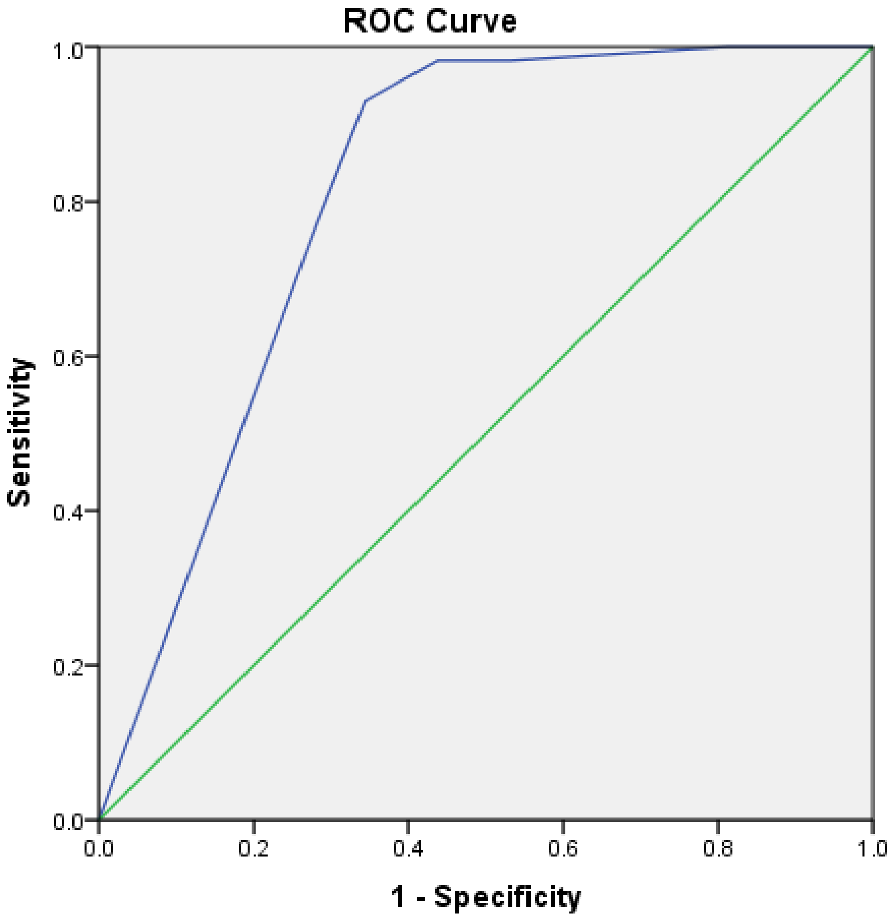

Figure 3. *ROC curve on CBS versus patient outcome (mRS) showing good quality of test.*

[a]CBS	Patients n (%)	[b]mRS ≤ 2 n (%)	mRS ≥ 3 n (%)
Number of cases	89		
≥ 6	83 (93.3)	57	26
≤ 6	6 (6.7)	0	6

[a]CBS;clot burden score ≥ 6 (low clot burden) ≤ 6 (high clot burden)
[b]mRS;modified Rankin Score ≤ 2 (good outcome) ≥ 3 (poor outcome)

Figure 4*. Patient outcome; CBS and mRS in 90 days*

REFERENCES

1. Catanese L, Tarsia J, Fisher M. Acute ischemic stroke therapy overview. Circ Res. 2017;120(3):541–558. doi:10.1161/CIRCRESAHA.116.309278.
2. Rink C, Khanna S. Significance of brain tissue oxygenation and the arachidonic acid cascade in stroke. Antioxid redox signal. 2011;14(10):1889–1903. doi:10.1089/ars.2010.3474.
3. Hinkle JL, Guanci MM. Acute ischemic stroke review. J Neurosci Nurs. 2007;39(5):285–293. doi:10.1097/01376517-200710000-00005.
4. Aziz ZA, Lee YYL, Ngah BA, Sidek NN, Looi I, Hanip MR, et al. Acute stroke registry Malaysia, 2010-2014: results from the National Neurology Registry. J Stroke Cerebrovasc Dis. 2015;24(12):2701–2709. doi:10.1016/j.jstrokecerebrovasdis.2015.07.025.

5. Balami JS, Hadley G, Sutherland BA, Karbalai H, Buchan AM. The exact science of stroke thrombolysis and the quiet art of patient selection. Brain. 2013;136(Pt 12):3528–3553. doi:10.1093/brain/awt201.
6. Bhaskar S, Stanwell P, Cordato D, Attia J, Levi C. Reperfusion therapy in acute ischemic stroke: dawn of a new era? BMC Neurol. 2018;18(8):1–26. doi:10.1186/s12883-017-1007-y.
7. Leung V, Sastry A, Srivastava S, Wilcock D, Parrott A, Nayak S. Mechanical thrombectomy in acute ischaemic stroke: a review of the different techniques. Clin Radiol. 2018;73(5):428–438. doi:10.1016/j.crad.2017.10.022.
8. Bracard S, Ducrocq X, Mas JL, Soudant M, Oppenheim C, Moulin T, et al. Mechanical thrombectomy after intravenous alteplase versus alteplase alone after stroke (THRACE): a randomised controlled trial. Lancet Neurol. 2016;15(11):1138–1147. doi:10.1016/S1474-4422(16)30177-6.
9. Fischer U, Kaesmacher J, Mendes Pereira V, Chapot R, Siddiqui AH, Froehler MT, et al. Direct mechanical thrombectomy versus combined intravenous and mechanical thrombectomy in large-artery anterior circulation stroke: a topical review. Stroke. 2017;48(10):2912–2918. doi:10.1161/STROKEAHA.117.017208.
10. Saver JL, Goyal M, Bonafe A, Diener H-C, Levy EI, Pereira VM, et al. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. N Engl J Med. 2015;372(24):2285–2295. doi:10.1056/NEJMoa1415061.
11. Morgan CD, Stephens M, Zuckerman SL, Waitara MS, Morone PJ, Dewan MC, et al. Physiologic imaging in acute stroke: patient selection. Interv Neuroradiol. 2015;21(4):499–510. doi:10.1177/1591019915587227.
12. Mokin M, Levy EI, Siddiqui AH, Goyal M, Nogueira RG, Yavagal DiR, et al. Association of clot burden score with radiographic and clinical outcomes following Solitaire stent retriever thrombectomy: analysis of the SWIFT PRIME trial. J Neurointerv Surg. 2017;9(10):929–932. doi:10.1136/neurintsurg-2016-012631.
13. Puetz V, Dzialowski I, Hill MD, Subramaniam S, Sylaja PN, Krol A, et al. Intracranial thrombus extent predicts clinical outcome, final infarct size and hemorrhagic transformation in ischemic stroke: the clot burden score. Int J Stroke. 2008;3(4):230–236. doi:10.1111/j.1747-4949.2008.00221.x.
14. Tan I, Demchuk A, Hopyan J, Zhang L, Gladstone D, Wong K, et al. CT angiography clot burden score and collateral score: correlation with clinical and radiologic outcomes in acute middle cerebral artery infarct. Am J Neuroradiol. 2009;30(3):525–531. doi:10.3174/ajnr.A1408.
15. Legrand L, Naggara O, Turc G, Mellerio C, Roca P, Calvet D, et al. Clot burden score on admission T2*-MRI predicts recanalization in acute stroke. Stroke. 2013;44(7):1878–1884. doi:10.1161/STROKEAHA.113.001026.
16. Sillanpaa N, Saarinen JT, Rusanen H, Hakomaki J, Lahteela A, Numminen H, et al. The clot burden score, the Boston acute stroke imaging Scale, the cerebral blood volume ASPECTS, and two novel imaging parameters in the prediction of clinical outcome of ischemic stroke patients receiving intravenous thrombolytic therapy. Neuroradiology. 2012;54(7):663–672. doi:10.1007/s00234-011-0954-z.
17. Tsivgoulis G, Katsanos AH, Schellinger PD, Köhrmann M, Varelas P, Magoufis G, et al. Successful reperfusion with intravenous thrombolysis preceding mechanical thrombectomy in large-vessel occlusions. Stroke. 2018;49(1):232–235. doi:10.1161/STROKEAHA.117.019261.
18. Mortimer AM, Little DH, Minhas KS, Walton ERJ, Renowden SA, Bradley MD. Thrombus length estimation in acute ischemic stroke: a potential role for delayed contrast enhanced CT. J Neurointerv Surg. 2014;6(3):244–248. doi:10.1136/neurintsurg-2013-010769.

VALUE OF CONE BEAM COMPUTED TOMOGRAPHY TO EVALUATE COMPLICATION OF INTRACRANIAL HAEMORRHAGE IN ENDOVASCULAR TREATMENT (EVT): A CASE REPORT

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Abstract
In this article, we evaluate the effectiveness of Cone Beam Computed Tomography, through a case study, in assessing the complication of intracranial bleeding during an endovascular treatment of brain arteriovenous malformation when compared to Multislice-Detector Computed Tomography performed immediately after the procedure. The image quality of Cone Beam Computed Tomography has enough diagnostic value in differentiating between haemorrhage, embolic materials and the arteriovenous malformation nidus to facilitate physicians to decide for further management of the patient.

Keywords; Cone beam computed tomography (CBCT): Brain arteriovenous malformation (AVM): Intracranial haemorrhage: Endovascular treatment BAVM: VasoCT

1. INTRODUCTION

Computed tomography (CT) is a well-established modality to diagnose intracranial diseases. As of late, CT-like imaging or Cone Beam Computed Tomography (CBCT) has been widely introduced into the angiography framework as a result of advancements in the flat detector technology and 3D reconstruction techniques.[1,2] The innovation has revolutionised interventional procedures in facilitating the on-table evaluation, and decision making in real-time.[3,4] We have been using CBCT application in the FD20/10 Philips angiography machine (VasoCT, Philips Healthcare, Best, The Netherlands) at our centre for a number of endovascular procedures, as well as for diagnostic purposes. This case report is to show the utility of CBCT as a tool to assess the complication of intracranial bleeding during an endovascular treatment of a brain arteriovenous malformation (AVM)

2. CASE

A 38-year-old gentleman presented with intracranial haemorrhage from a ruptured frontal lobe AVM. He was planned for staged embolisation, followed by surgical resection. The first embolization was uneventful, with approximately 25% of nidal occlusion achieved. Unfortunately, whilst the second embolisation session was being carried out, the microwire had accidentally torn the tortuous feeder artery upon cannulation, causing an extravasation of contrast. High-resolution peri-operative imaging was acquired using VasoCT protocol without iodinated contrast injection (VasoCT, Philips Healthcare, Best, The Netherlands).

The cross-sectional images showed brain parenchyma with evidence of a small haematoma. We were able to appreciate the distinct differences between the glue cast, nidus, and haemorrhage.

Based on these findings, decision to abandon the procedure was taken, and the patient was managed conservatively. He was extubated in the angiography suite with no evidence of neurological deficits. The gentleman was later scheduled for MDCT (Somatom Sensation 64, Siemens, Germany) and the results from VasoCT images and MDCT were compared. He was discharged from the hospital, in good condition, 4 days after the procedure.

3. DISCUSSION

CBCT images acquired by rotational angiography in the angiography suite has a promising new application that allows real-time image acquisition and visualisation of 3D anatomical structures. Previously, a conventional CT or MRI following the procedure needed to be performed, necessitating patient transfer to the CT or MRI scanner. CBCT enables access to cross-sectional imaging instantaneously during or after the procedure, without moving the patient from the angiography table.[2] The quality of these images is comparable to conventional MDCT.

In the illustrated case, the endovascular procedure performed was unfortunately complicated by intracranial haemorrhage. CBCT was performed immediately, which showed a distinct haematoma. The image quality was sufficient enough to provide a diagnostic value in differentiating the lesion, the high contrast embolic material artefacts, and the enhancement of the nidus. The glue cast seemed to give fewer artefacts when compared to conventional MDCT. Using the capability offered by CBCT, we were able to decide immediately whether the haemorrhage was significantly severe to warrant an urgent surgical evacuation of the haematoma, or otherwise.

CBCT image acquisition is also capable of generating a volumetric visualisation, which enables the user to reconstruct and evaluate more accurately the location of the haematoma with respect to the whole lesion. This will help surgeons plan their operative approach, should surgical or bail-out intervention is needed. We found the application of CBCT very useful for endovascular treatment of neurovascular diseases.

Good quality cross-sectional images can be obtained immediately for evaluation without the need for patient transfer. It also allows peri-procedural decision making to take place in complicated cases, as well as a supportive tool in dealing with procedural complications

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FIGURES

Figure 1: Digital substraction angiography of right internal carotid artery (ICA) showing the frontal lobe brain AVM nidus with early abnormal venous drainage (a), with fluoro-capture image showing contrast extravasation during check microcatheter run. Subsequent fluoro-capture image shows further extravasation of contrast (c), and single shot image during the procedure after NBCA (N-butyl cyanoacrylate) injection to secure the bleeder, showing NBCA cast at the bleeding point and feeder with residual contrast extravasation (d).

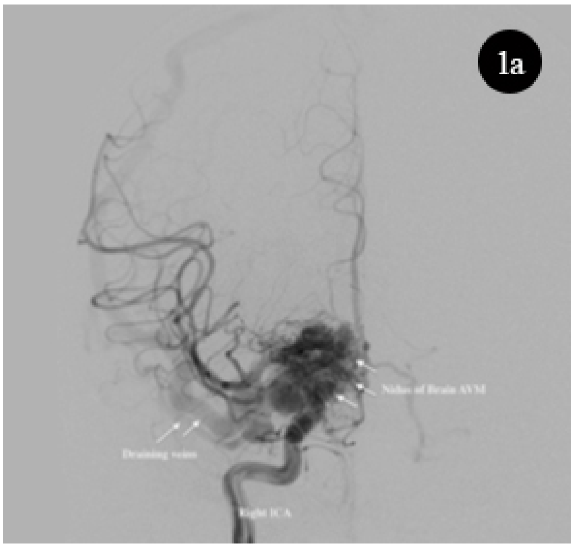

Figure 1a*: Digital subtraction angiography of the right internal carotid artery (ICA) showing the frontal lobe brain AVM nidus with early abnormal venous drainage*

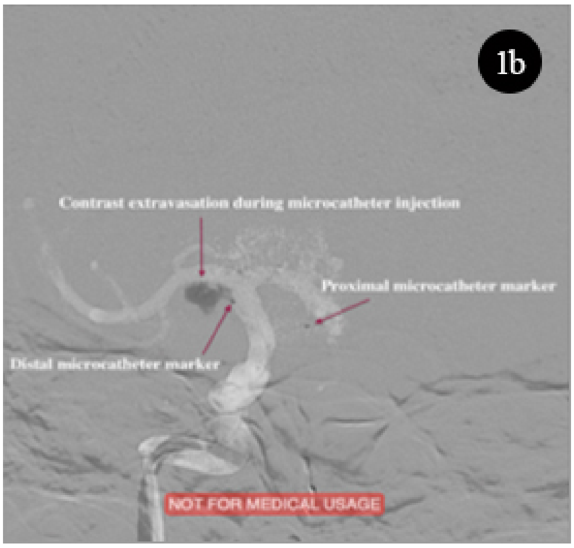

Figure 1b*: Capture fluoroscopy image showing contrast extravasation during check microcatheter run*

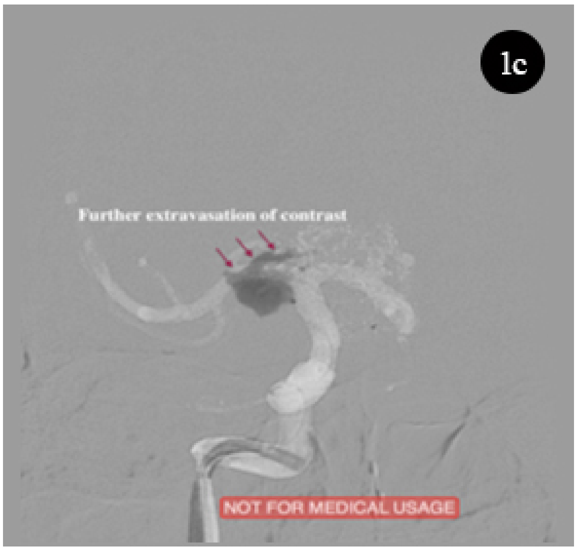

***Figure 1c**: Subsequent capture fluoroscopy image showing further extravasation of contrast*

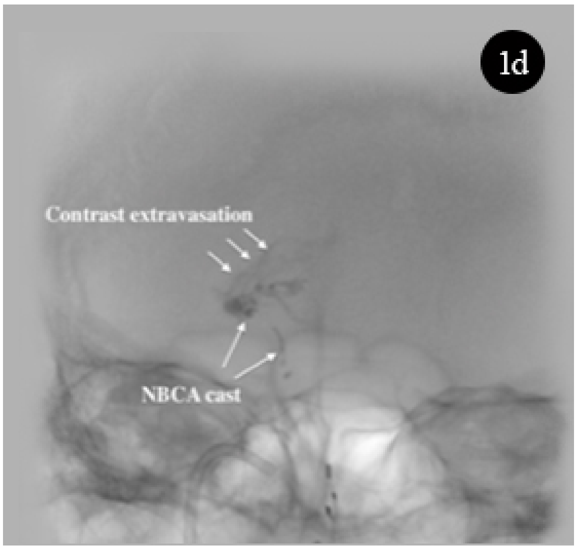

***Figure 1d**: Single shot image post NBCA (N-butyl cyanoacrylate) injection (to secure the bleeder), showing*

Figure 2: Reconstructed non-contrast, enhanced CBCT (VasoCT without contrast) shows different intensity between glue cast and contrast in nidus compared to haemorrhage (a), and the corresponding plain MDCT done immediately after the procedure, showing NBCA cast and haemorrage well differentiated and comparable to CBCT (b). The nidus not well depicted in this section

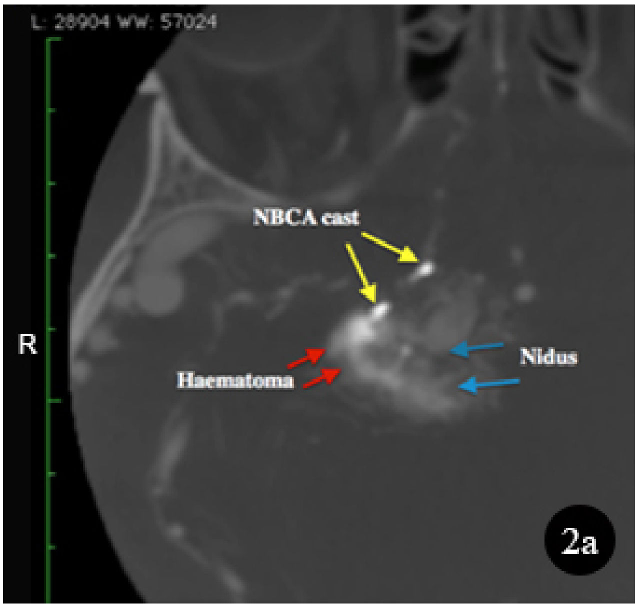

***Figure 2a**: Reconstructed non-contrast enhanced CBCT (VasoCT without contrast) shows different intensities between glue cast and contrast in the nidus, compared to haemorrhage.*

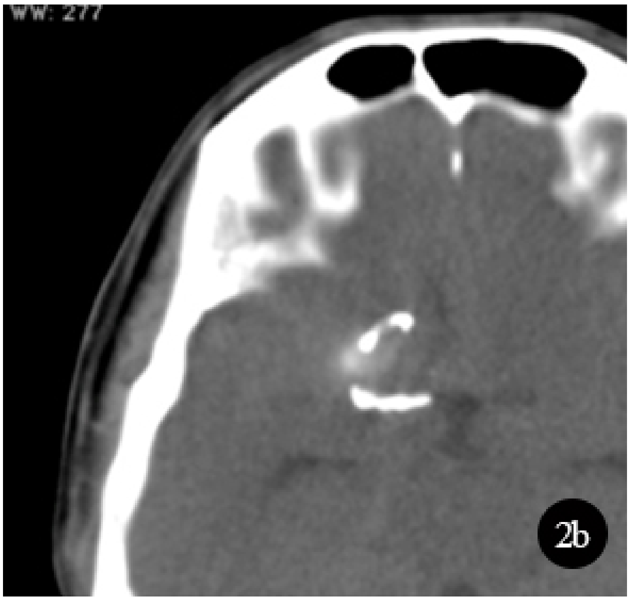

***Figure 2b:** NBCA cast and haemorrage in the corresponding MDCT section. Nidus is not well depicted in this section.*

REFERENCES

1. Benndorf G, Strother CM, Claus B, et al. Angiographic CT in Cerebrovascular Stenting. Am J Neuroradiol 2005; 26:1813–1818.
2. Kizilkilic O, Kocer N, Metaxas GE, et al. Utility of VasoCT in the treatment of intracranial aneurysm with flow-diverter stents. J Neurosurg 2012; 117:45-9.
3. Kamran M, Nagaraja S, Bryrne JV. C-arm flat detector computed tomography: the technique and its applications in interventional neuro-radiology. Neuroradiol 2010; 52:319-27.
4. Tokunaga S, Sambongi Y, Tsurusaki Y, et al. High-resolution cone-beam computed tomography localization of an iatrogenic vertebral arteriovenous fistula for trans-arterial target embolization. Journal of Neuroendovascular Therapy 2017; 11: 81–87.
5. Kamran M, Nagaraja S, Bryrne JV. C-arm flat detector computed tomography: the technique and its applications in interventional neuro-radiology. Neuroradiol 2010; 52:319-27

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