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Value of Tc-99m-Bicisate (ECD) Balloon Test Occlusion in Preoperative Assessment of Stroke Risk Prior to Carotid Artery Sacrifice.

Havrilla, A[1]. Raslan, O [2]. Muzaffar, R [2]. Botkin, C [1]. Hubble, W [1]. Hewing, D [1]. Sayed, M [3], and Osman, M [2].

[1] Doisy College of Health Sciences, St. Louis, MO, USA, [2] Department of Radiology, Division of Nuclear Medicine, St. Louis University , St. Louis, MO, USA, [3] Department of Clinical Oncology and Nuclear Medicine, Assiut University, Assiut, Egypt.

ABSTRACT:

Objectives: Internal carotid artery sacrifice (ICAS) may be required in treatment of cerebral aneurysms and tumours and is a high risk procedure. The interventional radiology balloon temporary occlusion test (IRBTO) paired with the two day Tc99m-bicisate brain perfusion study (BPS) can be a useful way to predict the outcome before occluding the artery in question. The purpose of this study is to examine the value of BPS exams as a predictor of stroke risk prior to ICAS. **Patients and methods:** 14 cases eligible for ICAS were retrospectively reviewed. IRBTO was positive if the patient developed neurological deficit during temporary IRBTO. The BPS exam was positive if the patient showed an area of focal hypo-perfusion on the occlusion phase, but not on the baseline study done 24 hours apart. The exam was negative if there was no perfusion abnormality on either phase. The results of the BPS were compared to occurrences of post-occlusion infarct. **Results:** ICAS was indicated in 14 cases [mean age 59.2± 25.2, M: F=2:12, aneurysm: tumour = 10:4]. One case with positive IRBTO: therefore did not proceed to BPS or ICAS. The remaining 13/14 (93%) cases had IRBTO, BPS, and subsequent ICAS. Of the remaining patients, 1/13 (8%) had a positive IRBTO and 2/13 (15%) had a positive BPS. Following ICAS (n=13), 4 cases developed infarct. Of those 4, 3 cases were negative on both exams (IRBTO and BPS). One case was positive on BPS and did not develop infarct. One case that was positive on both exams developed infarct after having ICAS at an outside facility. **Conclusions:** Combined IRBTO and BPS is an effective way in predicting focal neurological deficit prior to ICAS. Considering the risk of ICAS, the best patient outcomes are obtainable when both IRBTO and BPS are performed and negative.

Key words: IRBTO- Tc-99m-bicisate- ICAS.

Corresponding Author: Sayed , M. **Email:**mkeshk2010@gmail.com .

INTRODUCTION:

Permanent internal carotid artery sacrifice (ICAS) has become a routine for the management of aneurysms, pseudo-aneurysms, head and neck tumors, and carotid blowouts. Nevertheless, it is a high risk procedure [1-4]. Balloon Test Occlusion (BTO) has been performed to evaluate the collateral flow when a permanent ICAS is planned. However, up to 20% of patients have delayed neurologic sequel after permanent occlusion despite tolerating a 15 to 30 minutes test occlusion without symptoms [5,6]. There are various modified BTO neuro imaging techniques used to predict patients at risk for hypo-perfusion-related ischemic events after permanent ICAS including magnetic resonance imaging (MRI) [7], ^{133}Xenon-enhanced computed tomography [8 - 11], positron emission tomography (PET) [12], ^{99m}Tc-hexamethylpropyleneamine oxime single-photon emission computed tomography (SPECT) [13], regional cerebral oxygen saturation monitoring [14], transcranial Doppler ultrasonography [15], and monitoring cerebral oxygenation during balloon occlusion with multichannel continuous-wave near infrared spectroscopy (CW-NIRS) [16].In spite of these techniques, the rate of ischemic stroke following ICAS in patients who have passed these modified BTO tests remains high [17]. Many of these additional tests are expensive, complicated, or cumbersome to perform [18].The interventional radiology balloon temporary occlusion test (IRBTO) paired with the two day Tc99m-bicisate brain perfusion study (BPS) can be a useful way to predict the outcome before occluding the artery in question. The purpose of this study is to examine the value of IRBTO paired with the two day Tc99m-bicisateBPS exams as a predictor of stroke risk prior to ICAS.

MATERIALS AND METHODS:

Patients: Following approval by the Institutional Review Board, 14 cases (twelve women, two men; mean age 59.2± 25.2 yr) eligible for ICAS from October 2010 to December 2013 were retrospectively reviewed. Of these 14 cases, 10 had an aneurysm and the remaining4 cases had a tumor.

Methods: All cases underwent IRBTO paired with the two day Tc99m-bicisate BPS. IRBTO was performed by a board-certified interventional neuro-radiologist. Most procedures were performed with local and systemic analgesia only; light sedation was used in some cases. Conventional angiography was performed initially on 3 or 4 vessels (bilateral internal or common carotid arteries and unilateral or bilateral vertebral arteries) to evaluate the collateral circulation from the circle of Willis and to determine the position of the occlusion balloon. With the patient sedated but awake, a low pressure balloon (Hyper Form; Covidien, Irvine, California, USA) was angiographically introduced into the femoral artery, brought into position in the internal carotid artery of interest via a 5 or 6 Fr guide catheter, and inflated until contrast medium no longer flowed through the site of balloon occlusion for 30 min. After angiographically confirming continued occlusion at 30 min, the balloon was deflated and removed. Patients were monitored in a recovery area for post-procedural neurological and groin site complications prior to discharge on the same day or return to the previous level of inpatient care. **Intraprocedural neurological assessment:** An initial neurological assessment was performed before IRBTO including an assessment of motor and sensory function, visual fields, speech and cognition, and evaluation for cerebellar signs/higher cortical functions in both hemispheres. After confirming the patient's baseline status, IRBTO was conducted. Continuous evaluation of the patient's level of consciousness and repeated neurological assessment for development of neurologic deficits was carried out during test arterial occlusion. IRBTO was positive if the patient developed neurological deficit during temporary IRBTO. If the patient developed a neurological deficit, the balloon was quickly deflated. **Two day Tc-99m Bicisate brain perfusion study (BPS):** Occlusion phase and baseline BPS studies were acquired 24 hours apart. In occlusion phase BPS, approximately 740 MBq (20 mCi) of Tc-99m ***Bicisate*** was administered intravenously 5 min before termination of IRBTO. SPECT images were acquired immediately after IRBTO, using a rotating, large field-of-view, dual-head gamma camera (Bright View XCT; Phillips Healthcare) fitted with a low-energy, high-resolution collimator, and set at 140 keV with a 20% energy window. Gamma camera heads are mounted at 180°, and acquisition parameters used a 128 × 128 matrix, a contour orbit, 360° rotation, 3° per rotation, 64 views per head, 20 seconds per view. Reconstruction was performed using a Butterworth filter (cutoff frequency, 0.6 cm^{-1}; power, 10) generating sagittal, coronal, and trans axial slices. Patients returned for a baseline SPECT examination which was compared with the post-occlusive examination by a board-certified Nuclear Medicine physician. The BPS exam was positive if the patient showed an area of focal hypo perfusion on the occlusion phase but not on the baseline study done 24 h apart ***(Figure 1).*** The exam was negative if there was no perfusion abnormality between either phase ***(Figure 2)***. The results of the BPS were compared to occurrences of post-occlusion infarct. **ICAS:** Permanent ICAS was achieved by endovascular sacrifice, depending on the clinical situation. For patients who underwent permanent ICAS after IRTBO and BPS, additional follow-up clinical data was gathered for 6 months after the procedure by reviewing the electronic medical records and the follow-up imaging studies, if available.

Statistical analysis: Quantitative data was expressed as mean ± standard deviation, and qualitative data was expressed in percentage.

RESULTS:

ICAS was indicated in 14 cases (12 females and 2 males) with a mean age of 59.2± 25.2 years. Aneurysm was present in 10 patients and the remaining 4 had a tumor. One case had a positive IRBTO and therefore did not proceed to BPS or ICAS. The remaining 13/14 (93%) cases had IRBTO, BPS, and subsequent ICAS. Of the 13, 1/13 (8%) had a positive IRBTO and 2/13 (15%) had a positive BPS. Following ICAS (n=13), 9/13 (69%) who underwent preoperative IRBTO; BPS followed by ICAS had no ischemic complications during 6 months of follow-up. Of these patients, 8/9 (89%) had both a negative IRBTO and BPS. The remaining case had a positive BPS but still went on to have ICAS but did not develop post-occlusion infarct. However, 4/13 (31%) had post-occlusion infarct following ICAS. Of those, 3/4(75%) were negative on both exams (IRBTO and BPS). The remaining case was positive on both exams and developed post-occlusion infarct after having ICAS at an outside facility. A flow chart summarizing the distribution of cases that underwent IRBTO paired with the two day Tc99m-bicisate BPS is presented in **figure 3.**

DISCUSSION:

Occlusion of the internal carotid artery (ICA) for treating symptomatic large or giant carotid aneurysms or complex cranial base tumors can cause ischemic complications, even in patients who successfully tolerate the balloon test occlusion (BTO) of the ICA [19]. The incidence of immediate and delayed ischemic stroke due to hypo perfusion, excluding that for embolic complications, ranges from 2% to 20% [5, 6, 20, 21]No combination of BTO and ancillary tests has significantly reduced the incidence of ischemic events compared with BTO and clinical evaluation [22 - 23].The interventional radiology balloon temporary occlusion test (IRBTO) paired with the two day Tc99m-bicisate BPS can be a useful way to predict the outcome before occluding the artery in question. In the current study, 9/12 (75%) who passed preoperative IRBTO followed by ICAS had no ischemic complications during 6 months of follow-up. Only 3/12 (25%) developed post-occlusion infarct during follow-up, and 8/11 (73%) who passed preoperative BPS followed by ICAS had no ischemic complications during follow-up. Only 3/11(27%) developed post-occlusion infarct during follow-up. Although BTO can identify a group of patients at a lower risk for stroke after ICAS and has been resulted in reduction of the risk of ischemic complications after carotid occlusion, it does not eliminate the risk [7, 8, 11-13, 24-26]. The data suggests inadequate collateral circulation and thrombo-embolism are thought to be the two mechanisms causing ischemic complications after ICAS [27].

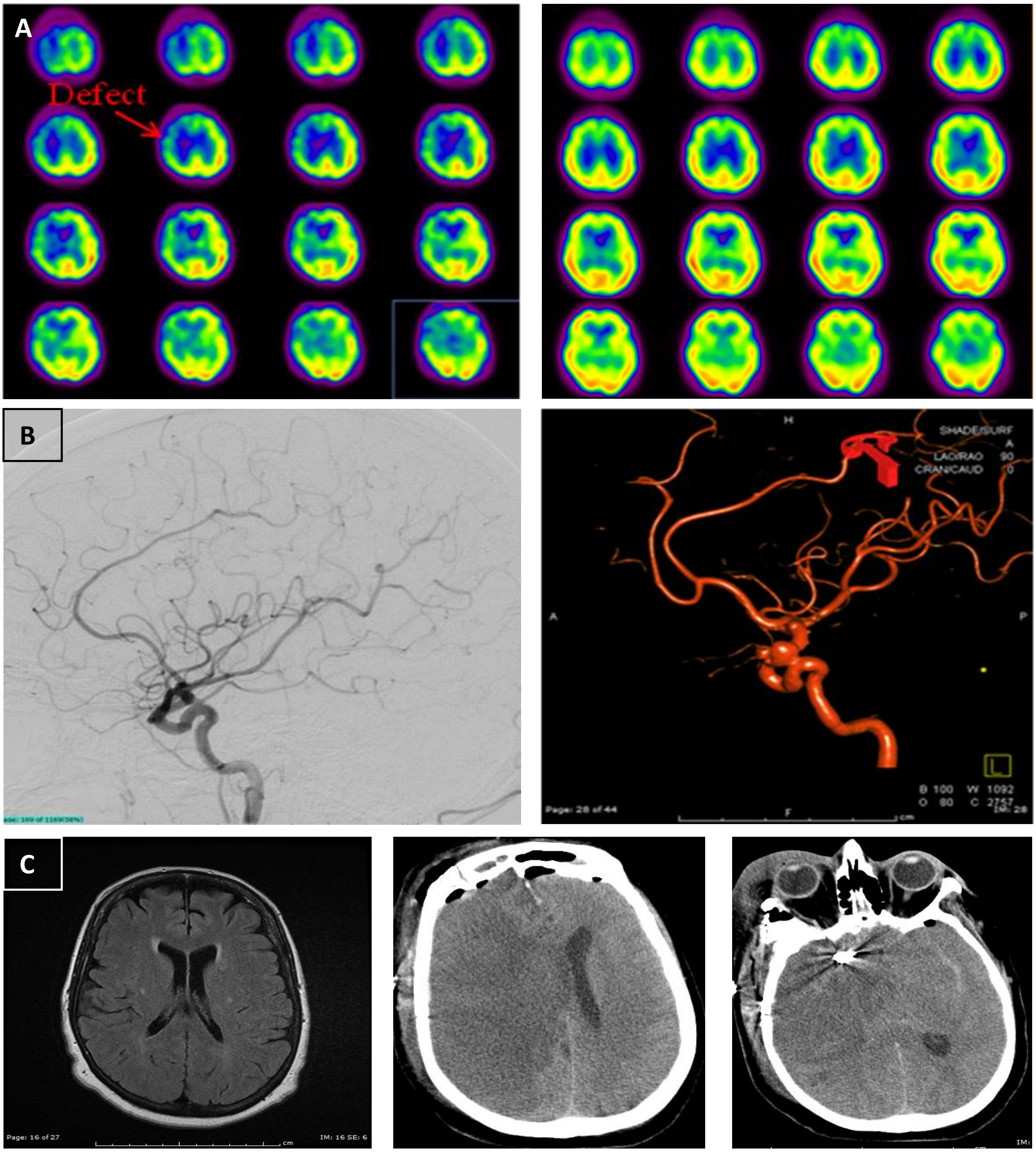

Figure 1: (A) Positive two day Tc99m-bicisate brain perfusion study. There is a defect in the right front temporal region (arrow) on the BPS after IRBTO (left) which is not present on the BPS at baseline (right). (B)Preoperative angiogram showed aneurysm of the internal carotid artery. (C) Preoperative MRI (left) and post-operative CT (middle and right); post operative CT showed post ICAS infarct.

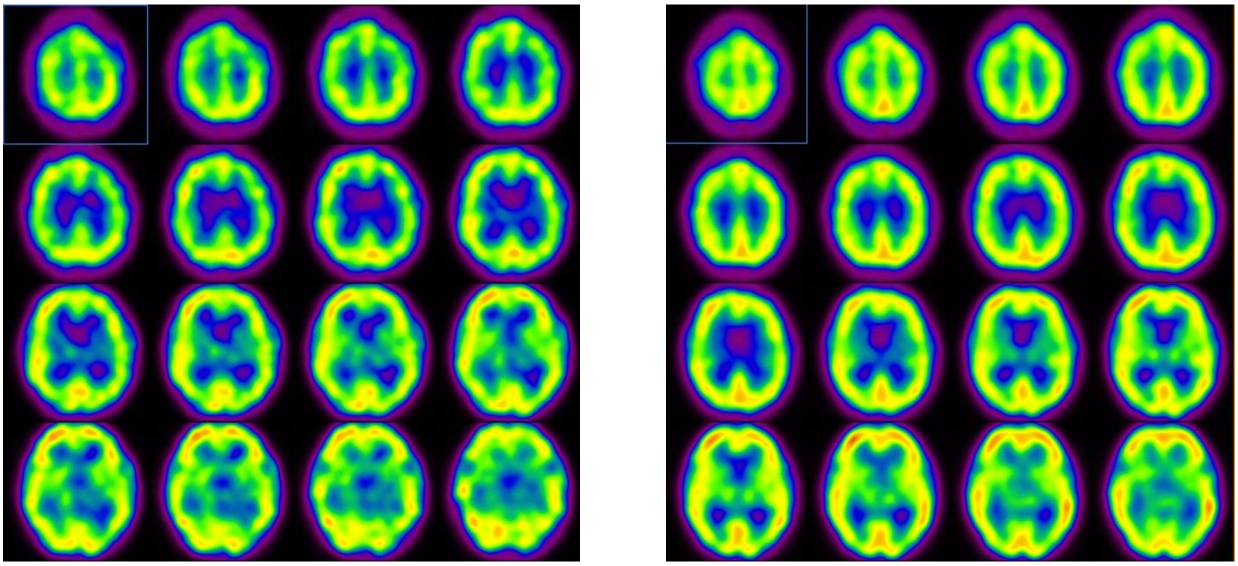

Figure 2: Negative two day Tc99m-bicisate brain perfusion study. There are no defects on either the BPS after IRBTO (left) or the BPS at baseline (right).

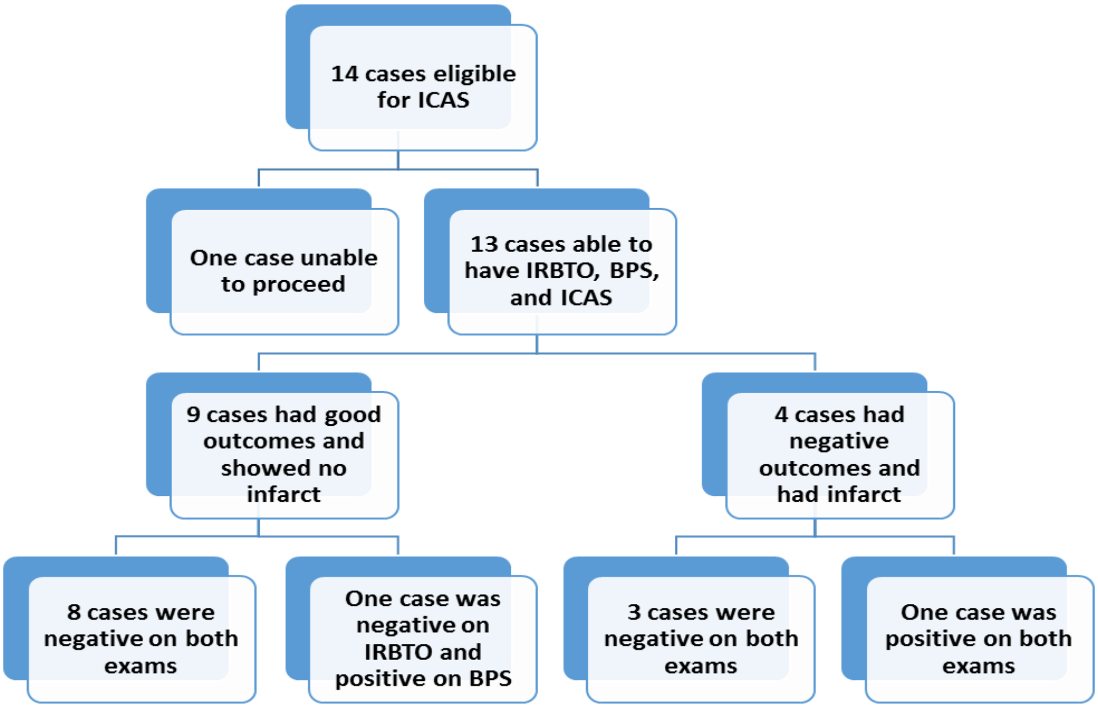

Figure 3: The distribution of cases that underwent interventional radiology balloon temporary occlusion test paired with the two day Tc99m-bicisate brain perfusion study

Although BTO cannot predict the risk of thromboembolism, which is a significant cause of delayed cerebral ischemia after carotid occlusion [28], inadequate collateral circulation can be detected by BTO before permanent ICAS. Linskey et al. [19] reported that the risk of ischemic complications was reduced by selective carotid occlusion following BTO and without preoperative testing of collateral flow, the rate of ischemic stroke after permanent ICA occlusion is high. Field et al. [29] evaluated the outcome in patients who underwent ICA occlusion following clinical BTO combined with quantitative cerebral blood flow (CBF) analysis with xenon-enhanced CT. They reported that permanent ICA occlusion can result in cerebral infarction despite normal clinical BTO results. They concluded that this combined method was a reliable technique for identification of patients at risk of ischemic infarction. Again, the protocols currently in use for BTO and adjunctive techniques do not appear to eliminate the risk of stroke related to hemodynamic factors. Some investigators use maneuvers that provoke ischemia such as a hypotensive or vasodilator challenge. These are used in conjunction with BTO and adjunctive techniques to unmask subtle insufficiencies in cerebral hemodynamic reserve [21, 30 - 31].Sugawara et al. [32] evaluated the usefulness of SPECT during BTO and evaluated the changes in regional CBF and regional cerebral perfusion reserve (CPR) after permanent carotid occlusion. In 7 patients who were tolerant of BTO and subsequently underwent permanent carotid occlusion, quantitative measurements of CBF (in mL/100 g/min) using Xe-133 inhalation methods were performed at rest and after enhancement with 1 g of acetazolamide. The CBF measurements were performed before and after permanent carotid occlusion and were repeated periodically during follow-up. In one patient, a transient hemiparesis occurred soon after permanent occlusion of the right ICA when the blood pressure dropped. In another patient, a small infarction that was probably due to a small thrombo-embolism was incidentally detected on follow-up MRI. No permanent neurologic deficit was observed in any patient. They also reported that CPR decreased after carotid occlusion even though resting CBF did not change. In these settings, an ischemic event might occur when cerebral perfusion pressure drops. Thus, some patients with normal CBF during BTO may still have a risk of ischemic events after permanent carotid occlusion because of reduced CPR. Also, BTO in conjunction with a hypotensive challenge has been reported to be useful for decreasing the false-negative rate [21, 33 - 35]. Standard et al. [21] reported that 9% of patients showed neurologic deficits during normotensive BTO, whereas 21% showed deficits during hypotensive BTO. They concluded that brain SPECT is useful for evaluating brain tolerance to carotid occlusion and is sensitive in detecting subclinical hypo-perfusion during temporary BTO. They recommend assessment of CPR in order to predict the potential risk of hemodynamic ischemia and to follow-up patients after permanent carotid occlusion. Whether this additional information increases the predictive value of BTO is, however, still controversial. A fundamental problem with the literature on BTO is that patients who have a positive test by one of the many different protocols or techniques generally do not go on to sacrifice. This makes it very difficult to determine the accuracy of the procedure in predicting stroke risk. In the current study, one case was positive on both IRBTO and BPS who developed an infarct after having ICAS at an outside facility. This suggests the accuracy of the combined IRBTO and BPS in predicting focal neurological deficit prior to ICAS. Limitations of the current study include the retrospective nature of the study and the small number of patients who underwent permanent ICA occlusion.

CONCLUSIONS: Combined IRBTO and BPS is an effective way in predicting focal neurological deficit prior to ICAS. Considering the risk of ICAS, the best patient outcomes are obtainable when both IRBTO and BPS are performed and negative.

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