Can the Human Eye Match a Computer Algorithm in Identifying Hypoperfusion in Asymptomatic Carotid Artery Stenosis?

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BACKGROUND

Perfusion weighted imaging on MRI (MRP) and computerized tomography perfusion (CTP) are increasingly required to manage large vessel disease. Computerized algorithms can quantify perfusion data, but the programs are expensive and not widely used outside acute stroke evaluation. We aimed to determine how well human observers can identify asymmetries in cerebral perfusion images compared with an automated computer algorithm.

HYPOTHESIS

Clinicians trained in Vascular neurology, Neurological Surgery, Interventional Radiology, or Neuroradiology will be able to identify whether there is side-to-side (hemispheral) asymmetry in patients with asymptomatic unilateral carotid artery stenosis as well as a computerized algorithm.

METHODS

Participants

Ten clinicians experienced in treating carotid artery disease (4 vascular neurologists, 3 neuroradiologists, 1 vascular surgeon, 1 neurosurgeon, 1 interventional radiologist) were given 28 post-processed, color-coded, axial-slice MRI perfusion (MRP) scans from patients in the Carotid Revascularization Endovascular versus Stenting Trial – Hemodynamics (CREST-H) study, an independently funded, NINDS-sponsored trial ancillary to the Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis study (CREST-2).

Figure 1 shows an example of hemispheral asymmetry in flow using maps of time to peak (TTP), mean transit time (MTT), cerebral blood volume (CBV), cerebral blood flow (CBF), and time to maximum (Tmax). TTP was chosen as the primary measure for the CREST-H study and was used in this analysis. White arrows indicate the flow delay on the side of stenosis.

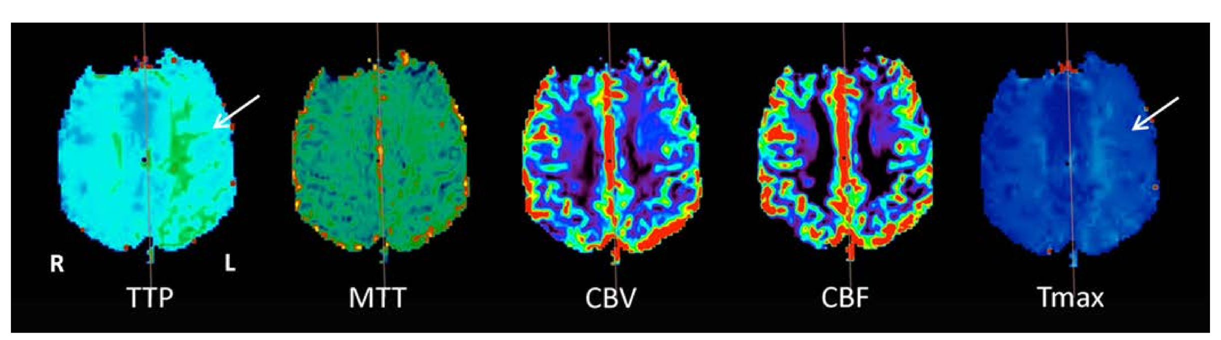

Figure 1. Examples of flow-related imaging output.

METHODS, cont'd

Patient inclusion/exclusion criteria

- >70%, unilateral, asymptomatic internal carotid artery (ICA) stenosis.
-age ≤86
-fluent in English
-no contralateral ICA occlusion or stenosis ≥70%
-no pre-existing diagnosis of dementia
-no Hx of severe head trauma or current major depression
-education ≥8 years

Imaging algorithm

Patients had varying degrees of time-to-peak (TTP) delay on the side of stenosis, ranging from 0 to 2 secs, quantified by a semi-automated system that computes quantitative perfusion maps, using deconvolution of tissue and arterial signals (Olea, Cambridge, MA). A minimum volume of 10cc was required for a given TTP delay. The sequences used in CREST-H are very similar to clinical imaging algorithms.

Procedure

Clinicians were asked to determine asymmetry (y/n) and side of occlusion for each case. Number of correct responses that matched the computer output were tallied.

Images.

Figure 2 shows examples of images from 4 cases viewed by the study clinicians illustrating different degrees of TTP delay.

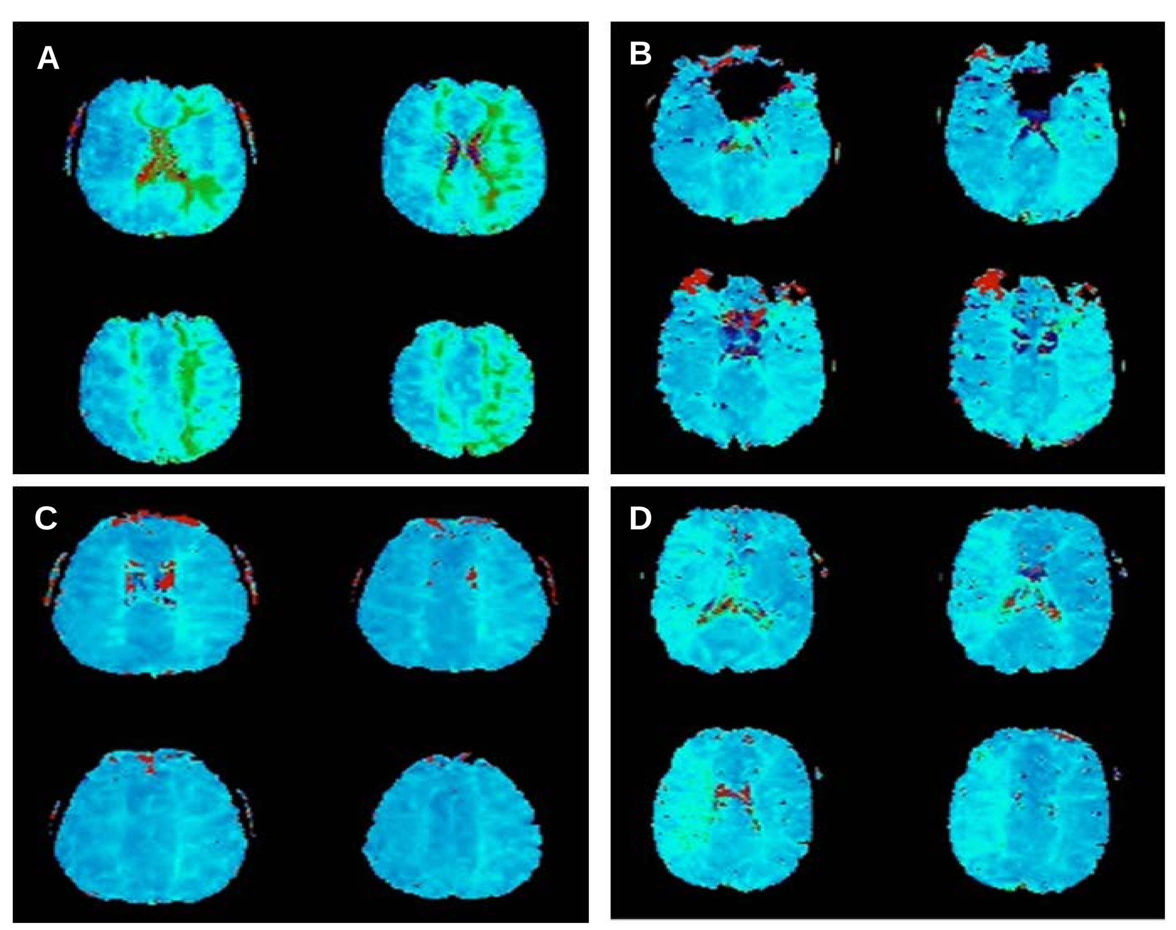

Figure 2 A-D shows cases 23, 14, 1 and 9 respectively.

RESULTS

We averaged correct responses by the 10 clinicians for cases at each increment of TTP delay; At TTP delays ≥1.5 seconds, accuracy was ≥80%. At 1.25 sec accuracy fell to 60%, and at ≤ 1 sec, accuracy was ≤50%. For TTP=0 (no asymmetry), accuracy was 71%. The **Table** shows the average percent correct by the 10 clinicians for each increment of TTP delay, and **Figure 3** illustrates the declining accuracy below 1.5 seconds in graphic form.

TTP Delay (sec, calculated)	Averaged % correct
0.00	71
0.50	19
0.75	44
1.00	30
1.25	60
1.50	80
1.75	100
2.00	80

Table. Percent correct assessment of hemispheral asymmetry for clinicians by visual inspection compared with computer-generated TTP delay.

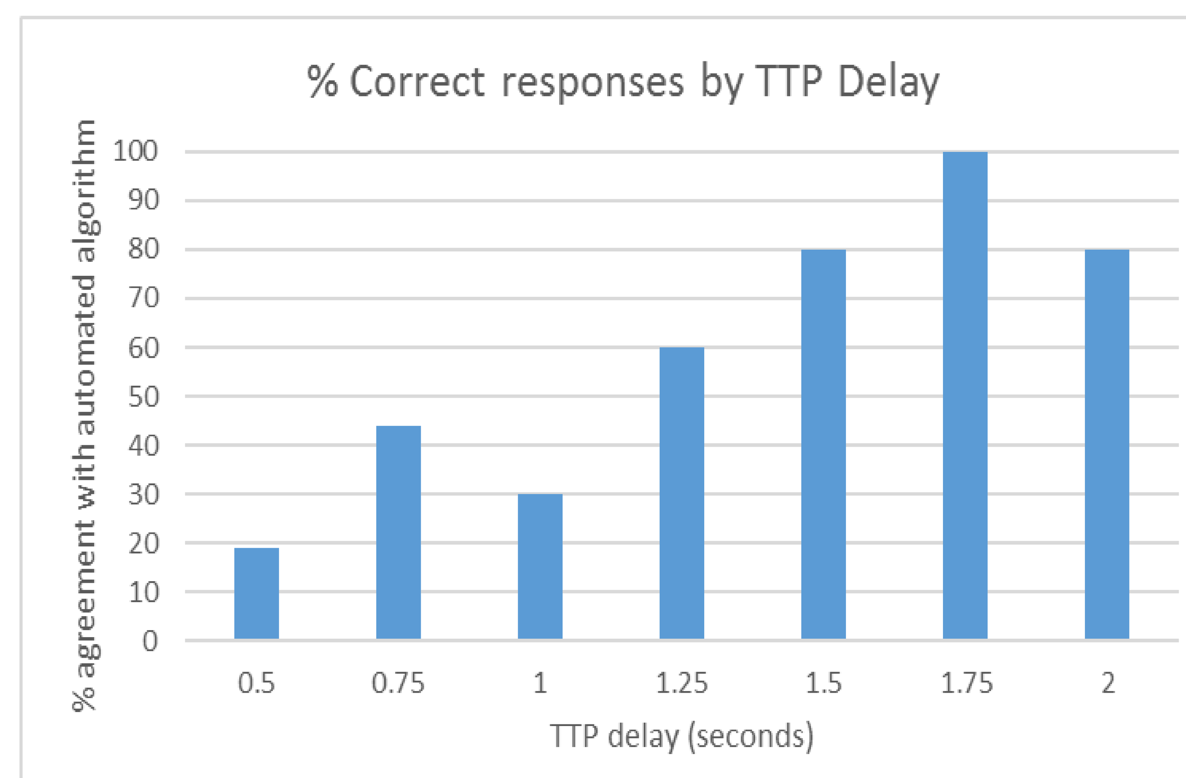

Figure 3. For each incremental TTP delay from 0.5 seconds to 2.0 seconds, the average agreement with the computer among the 10 clinical readers is shown. For TTP delays of ≥1.5 seconds the clinicians were ≥80% in agreement with the automated algorithm. For lesser degrees of TTP delay, accuracy declined.

DISCUSSION

Assessment of flow studies in the brain is becoming increasingly part of stroke management. For example, automated software currently supports decision-making in the setting of acute stroke in determining the need for endovascular therapy in the extended time window. Because many stroke physicians as well as general neurologists are faced with the need to interpret studies themselves in clinical settings, a need has arisen to develop imaging methods that present data in a clear and consistent way that allows the average stroke physician to interpret studies easily.

One additional decision-making challenge is in asymptomatic high-grade carotid stenosis. The CREST-2 trial is designed to determine if revascularization by endarterectomy or by carotid artery stenting in addition to intensive medical management helps prevent subsequent stroke or death in this population. The CREST-H trial was initiated to determine if a subset of CREST-2 randomized patients with hemodynamic impairment on the side of stenosis and mild cognitive impairment will benefit cognitively from revascularization. An automated algorithm currently produces a hemodynamic asymmetry measure based on a minimum TTP delay on the hemisphere ipsilateral to the target stenotic ICA of at least 0.5 seconds compared to the contralateral hemisphere. The current study was designed to determine how accurate experienced stroke clinicians can be in assessing a hemispheral asymmetry by eye, as they might be asked to do in a real world clinical setting, faced with a clinical decision about the advisability of carotid revascularization in an otherwise "asymptomatic" carotid stenosis.

CONCLUSION

Visual impression of hemodynamic asymmetry among experienced clinicians was reasonably accurate for TTP delays ≥1.5 seconds, but declined with more subtle asymmetries. Depending how much of a hemodynamic impairment is found to correlate with cognitive change within the CREST-H study, experienced clinicians may perform as well as an automated algorithm for identifying moderate degrees of hemodynamic asymmetry on clinical perfusion scans.

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