

Imaging of vertebral artery stenosis: a systematic review

S Khan, G C Cloud, S Kerry, H S Markus

J Neurol Neurosurg Psychiatry 2007;**78**:1218–1225. doi: 10.1136/jnnp.2006.111716

Centre for Neuroscience, St George's University of
London, Cranmer Terrace, London , UK

Resident 許程傑

Introduction

- **Posterior circulation stroke** account for fifth of strokes, 20–25% be due to stenosis of vertebral artery, with embolism being the likely mechanism.
- Management of vertebral artery stenosis remains uncertain.
- Surgical revascularisation for vertebral artery stenosis is complex for difficult surgical access.
- **Angioplasty and stenting** are technically feasible

Introduction

- Traditional perception of vertebrobasilar strokes has benign prognosis compared with carotid events.
 - Reluctant to investigate for vertebral stenosis
- Systematic review demonstrated that the risk of **subsequent stroke or death** are significantly higher in the **acute phase** of vertebrobasilar events than **carotid territory events**

Flobman E, Rothwell P. Prognosis of vertebrobasilar transient ischaemic attack and minor stroke. Brain 2003;126:1940–54.

Introduction

- Non-invasive imaging of VA stenosis is more complex compared with CA stenosis
- **Duplex ultrasound (DUS)**
 - clear image for carotid stenosis, limited visualisation of VA
- **Intra-arterial angiography (IAA)**
 - the gold standard but carries a risk of iatrogenic stroke of (1–2%)
- **Non-contrast MRA**
- **Contrast enhanced MRA (CE-MRA) , contrast enhanced CTA** as alternatives to the gold standard of IAA

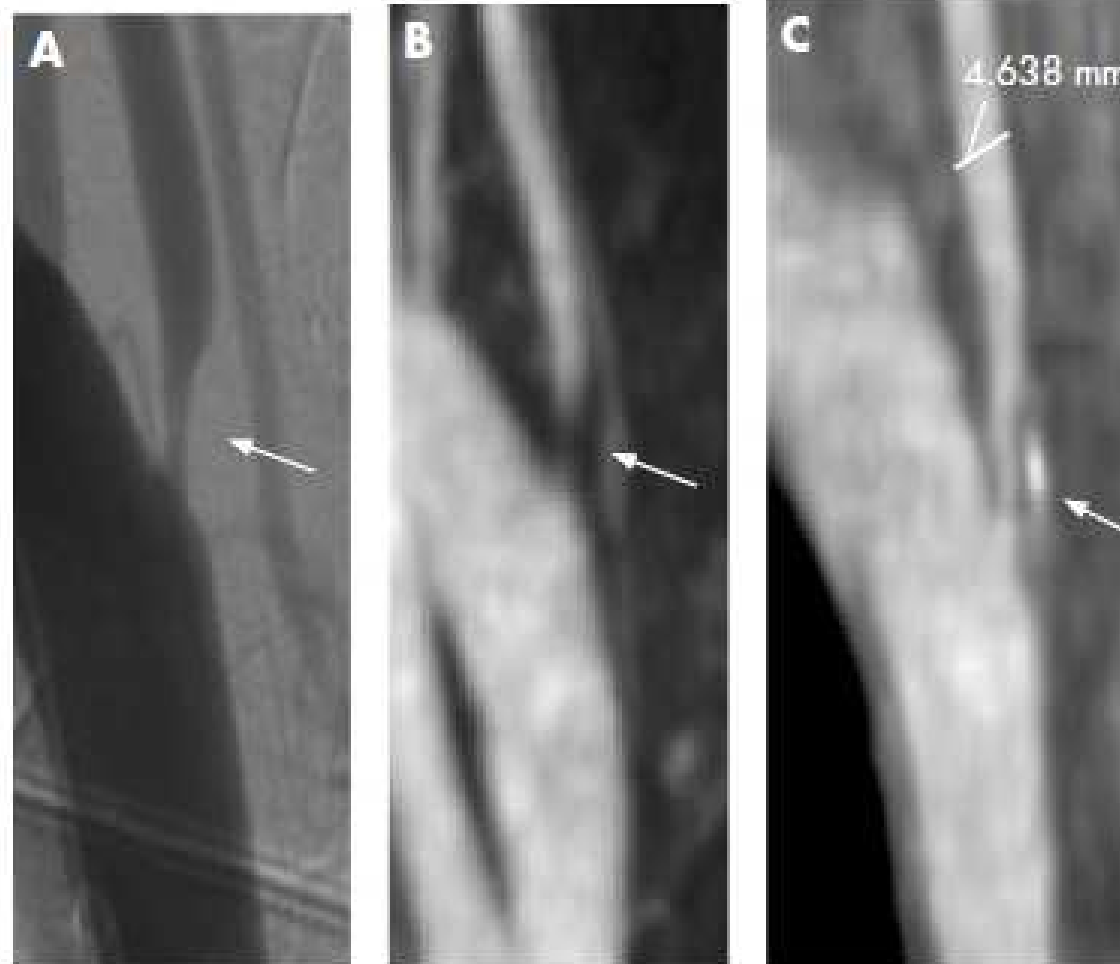


Figure 1 Intra-arterial angiography (IAA), extracranial contrast enhanced magnetic resonance angiography (CE-MRA) and computed tomographic angiography (CTA), demonstrating right vertebral artery stenosis in a 64-year-old patient who presented with a posterior circulation stroke. (A) IAA with right subclavian artery injection; (B) extracranial CE-MRA maximum intensity projection image; (C) extracranial CTA sagittal reformatted image.

Introduction

- **Meta-analysis of carotid artery stenosis**
- **CE-MRA** is more sensitive and specific than *ultrasound, non-contrast MRA and CTA*

Wardlaw JM, Non-invasive imaging compared with intra-arterial angiography in the diagnosis of symptomatic carotid stenosis: a meta-analysis. *Lancet* 2006;367:1503–12

- Fewer studies have compared these imaging modalities in VA stenosis.
- VA differs significantly anatomically from the ICA

Introduction

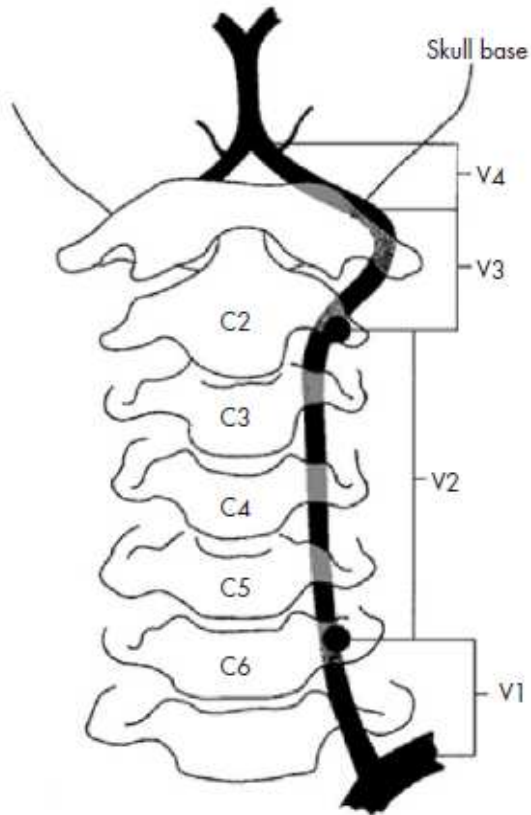


Figure 2 Schematic diagram illustrating the four segments of the vertebral artery

- The VA is structurally divided into four sections
- V1–V3 form the extracranial vertebral artery
- V4 forms the intracranial vertebral artery.
- The VA is much smaller (3–5 mm) than the ICA
- It is asymmetrical, with up to 15% of the population having one vertebral artery which is atretic.

Introduction

- 50% have a dominant left VA
- 25% a dominant right VA
- 25% have both VA of similar calibre
- **Conduct a systematic review of the literature to determine the diagnostic accuracy of VA stenosis**
 - DUS
 - Contrast and non-contrast enhanced MRA
 - CTA

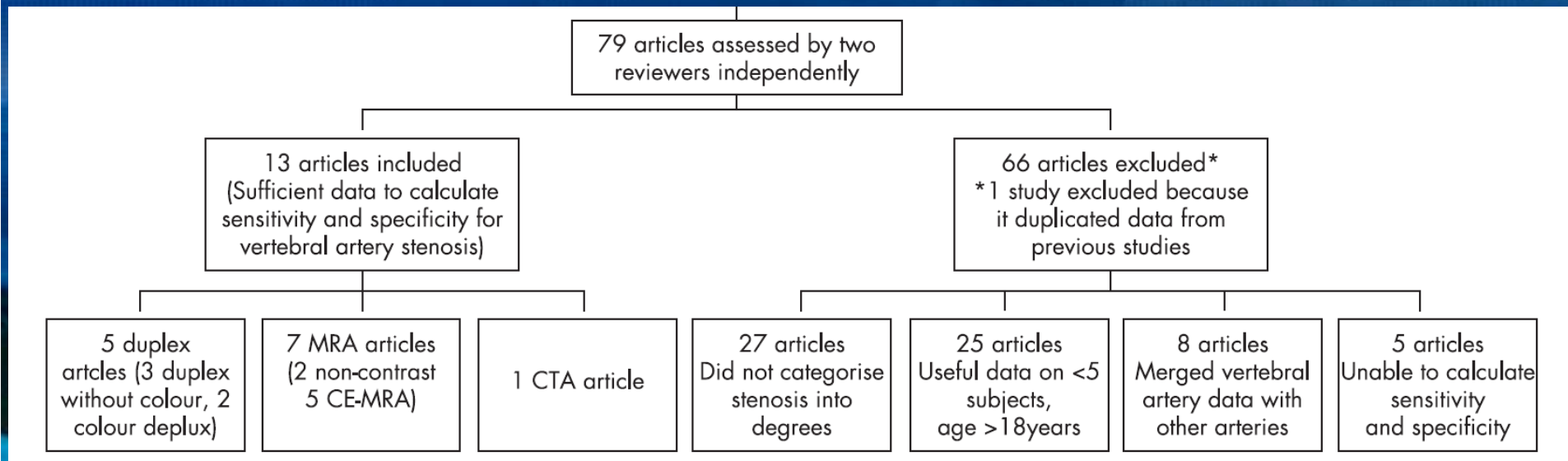
METHODS

- Data sources and study selection
- Medline, Embase and Pubmed (final search date 13 July 2006)
- Inclusion criteria
 - VA stenosis or occlusion.
 - IAA as the standard reference to validate the accuracy of **DUS, MRA and CTA**
- Exclusion criteria
 - Did not categorise stenosis into degrees
 - Merged vertebral artery data with other vessels

METHODS

- Analysis methodology
- Sensitivity and specificity percentage values were calculated for categories of stenosis by pooling data
 - **50–99%**
 - **50–69/70%**
 - **70–99%**
 - **100% (occlusion)**

RESULTS



RESULTS(Stenosis detection: 50–99%)

- **Ultrasound(duplex without colour)-2**
 - Pooled sensitivity: **70.2 %**
 - Specificity: **93.4%**
- **Ultrasound(duplex with colour)-2**
 - Pooled sensitivity: **70.2%**
 - Specificity: **97.7**
- For diagnosing 50–99% stenosis versus diagnosing 50% stenosis or 100% (occlusion).

RESULTS(Stenosis detection: 50–99%)

- **Non-contrast MRA studies-2**
 - Pool sensitivity: **53.8%**
 - Specificity: **88%**
- **CE-MRA-4**
 - Pooled sensitivity: **93.9%**
 - Specificity: **94.8%**
- **CTA-1**
 - Sensitivity: **100%**
 - Specificity: **95.2%**

RESULTS (Stenosis detection: 50/69–70%)

	Sensitivity	specificity
Colour duplex-1	61.5%	98.7%
CE-MRA-1	50%	95.8%
CTA-1	100%	95.0%

RESULTS(Stenosis detection: 70–99%)

	Sensitivity	specificity
Colour duplex-1	65.2%	99.3%
CE-MRA-2	83.3%	98.5
CTA-1	100%	100%

RESULTS(occlusion)

	Sensitivity	specificity
Colour duplex-3	83.3%	100%
MRA-1	100%	100%
CE-MRA-4	89.5%	99.6%

- The single CTA study did have one occluded artery but did not comment if this was seen on both CTA and IAA

Discussion

- Scarcity of good quality studies validating the accuracy of diagnosing VA stenosis
- 50–99% as their cut-off point
 - Cause of stroke and further intervention
- **CE-MRA had the highest sensitivity** followed by CTA, colour duplex and duplex without colour.
- **VA is much smaller than carotid artery**
 - Reduce the accuracy of the stenosis estimation

Discussion-*ultrasound*

- Ultrasound is non-invasive, cheaper and usually more readily available.
- Cannot visualise the full length of the VA, and rely on flow disturbance
 - Only present with more severe stenosis
- Does not directly show the site of stenosis.
- Difficulty of differentiating between dissection and atherosclerotic disease.

Discussion-*CE-MRA*

- Disadvantages
 - Cost
 - Contraindication in patients with metallic devices such as pacemakers
 - Claustrophobia

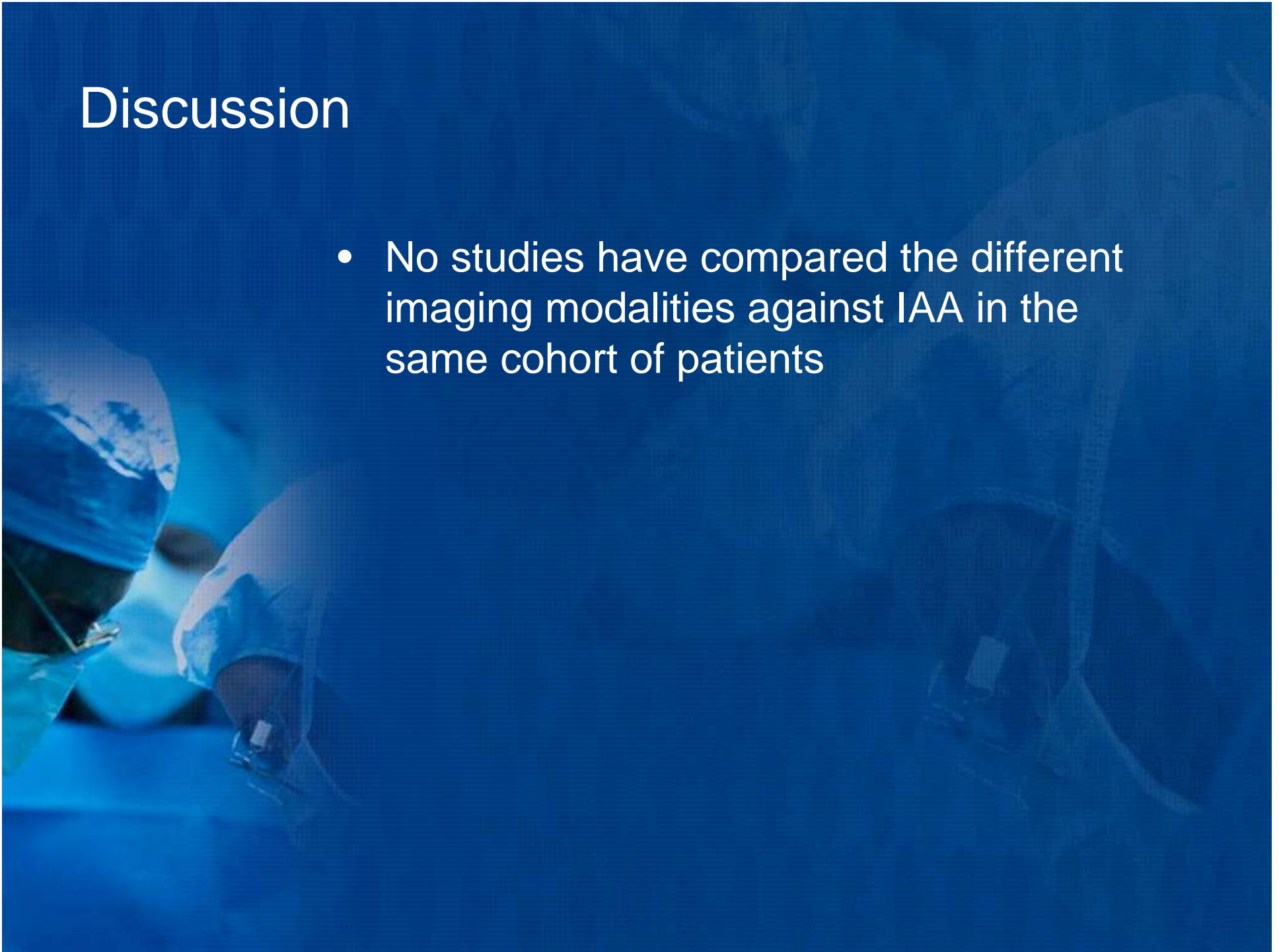
Discussion-CTA

- Comparable sensitivity and specificity to CE-MRA.
- It is *cheaper and suitable*
- Radiation, and a potentially nephrotoxic contrast agent
- Inaccurate for heavily calcified stenosis.
- **CTA increasingly being used as the modality of choice to replace IAA**

Bash S, Intracranial vascular stenosis and occlusive disease: evaluation with CT angiography, MR angiography, and digital subtraction angiography. Am J Neuroradiol 2005

Discussion

- No studies have compared the different imaging modalities against IAA in the same cohort of patients



Journal of Neuroradiology (2013)

ORIGINAL ARTICLE

Non-invasive evaluation of proximal vertebral artery stenosis using color Doppler sonography and CT angiography

*Department of neurology, 3rd Medical Faculty, Charles University,
Prague, Czech Republic
Department of Neurology, General hospital, Jihlava, Czech Republic*

- CDS a well available **screening, is employed as a first choice method**
- Depend on individual skill and on a well-defined examination procedure
- Some studies, found the **CDS results highly comparable with those of DSA**

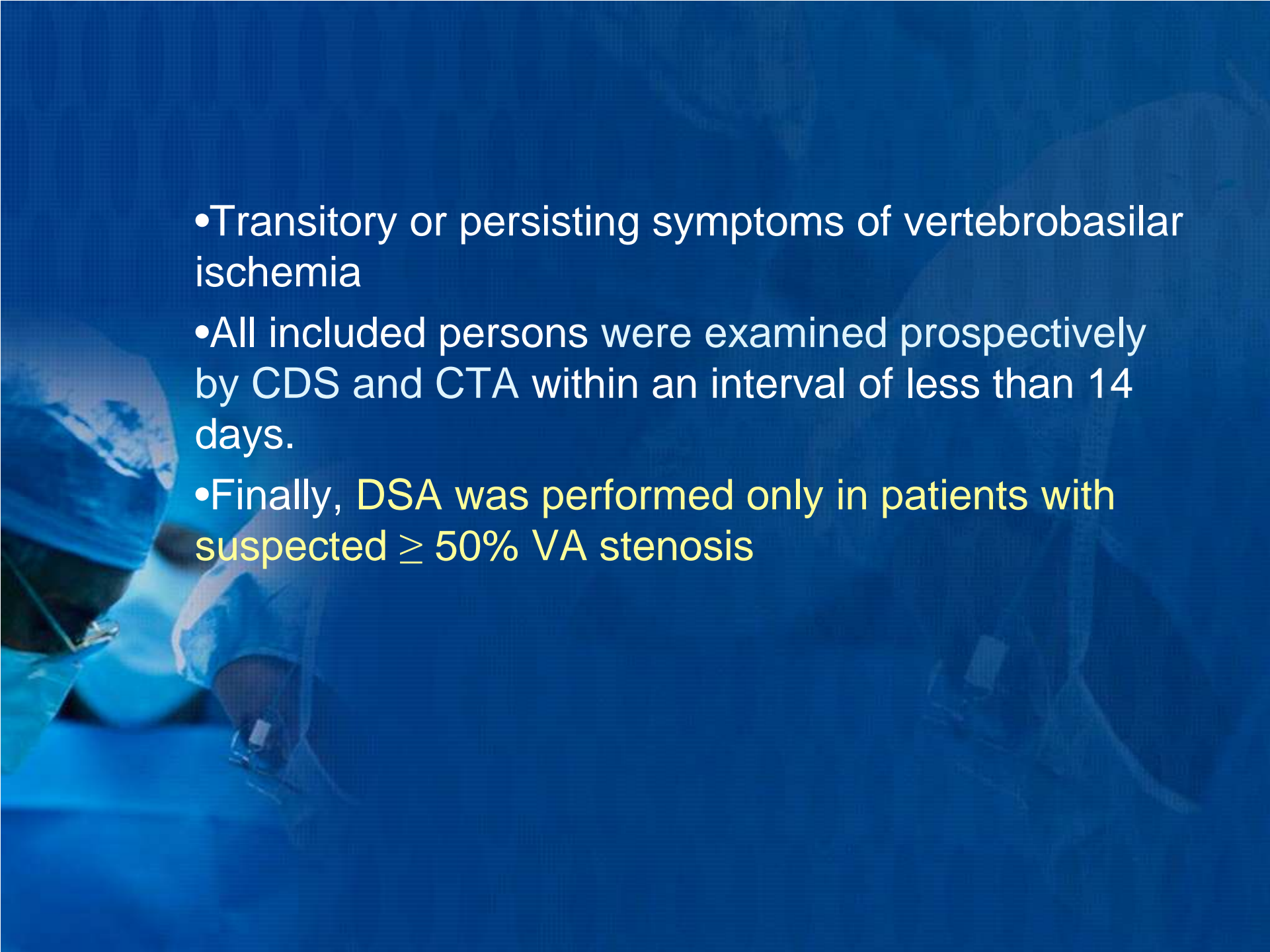
- Hua Y, Color doppler imaging evaluation of proximal vertebral artery stenosis. Am J Roentgenol 2009;193:1434—8.
- Yurdakul M, Tola M. Doppler criteria for identifying proximal vertebral artery stenosis of 50% or more. J Ultrasound Med 2011;30:163—8.

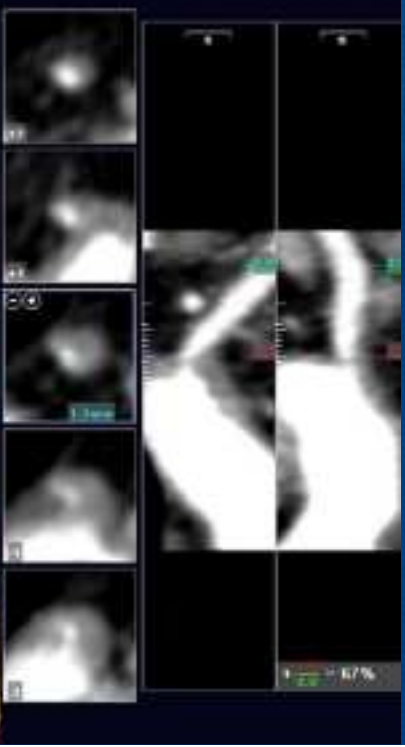
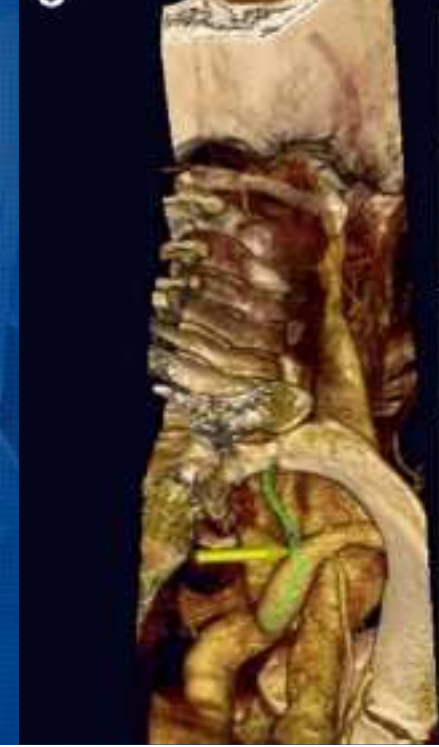
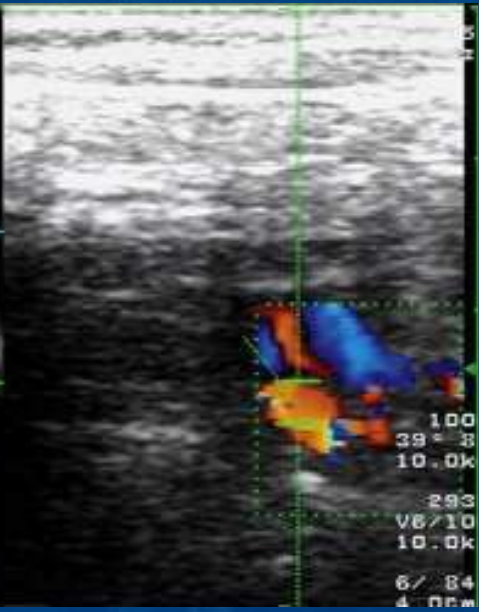
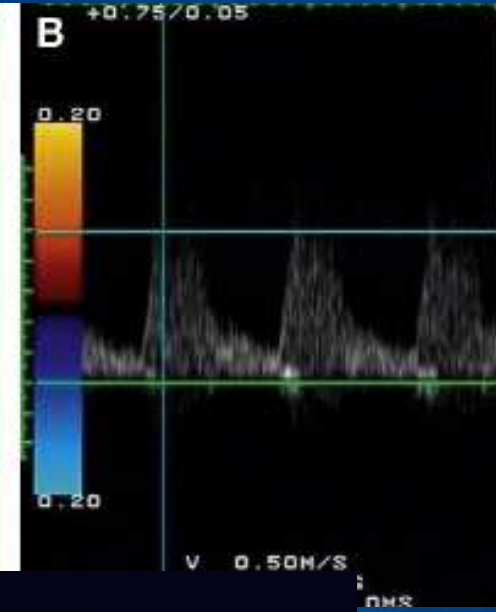
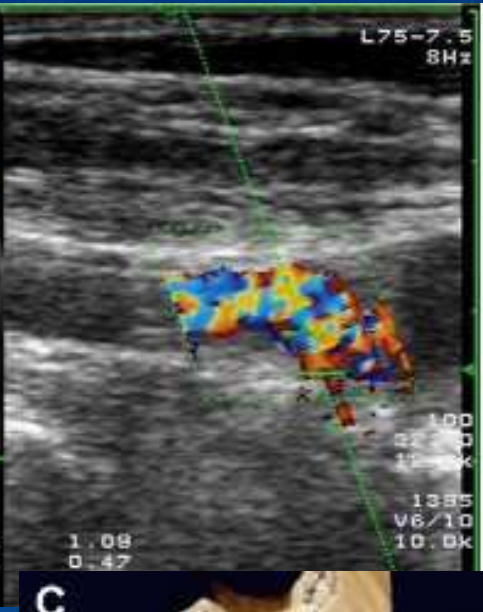
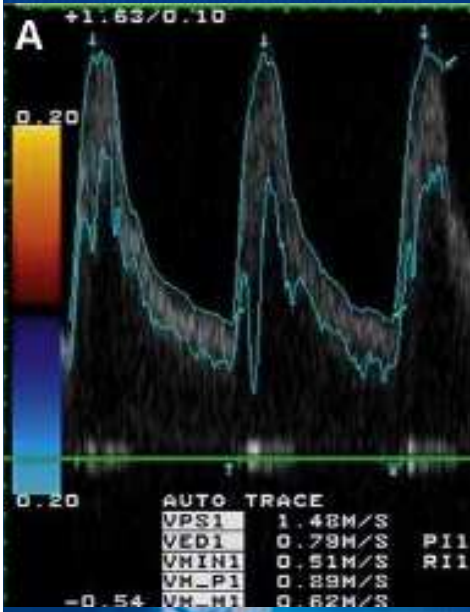
- **Aim of the study**

1. **Test the usefulness and accuracy of the non-invasive combination of CDS and CTA**

2. **To restrict DSA only for final proof of high grade stenosis**

- Select procedures more suitable for routine screening,

- 
- Transitory or persisting symptoms of vertebrobasilar ischemia
 - All included persons were examined prospectively by CDS and CTA within an interval of less than 14 days.
 - Finally, DSA was performed only in patients with suspected $\geq 50\%$ VA stenosis



RESULTS

- The statistically significant Pearson's correlation (**0.847**, $P < 0.001$) demonstrates the strong agreement between the two methods.
- Correlations between the CTA and DSA results in VA stenoses $\geq 50\%$, **0.823** ($P < 0.001$)
- **CTA might replace DSA as gold standard**

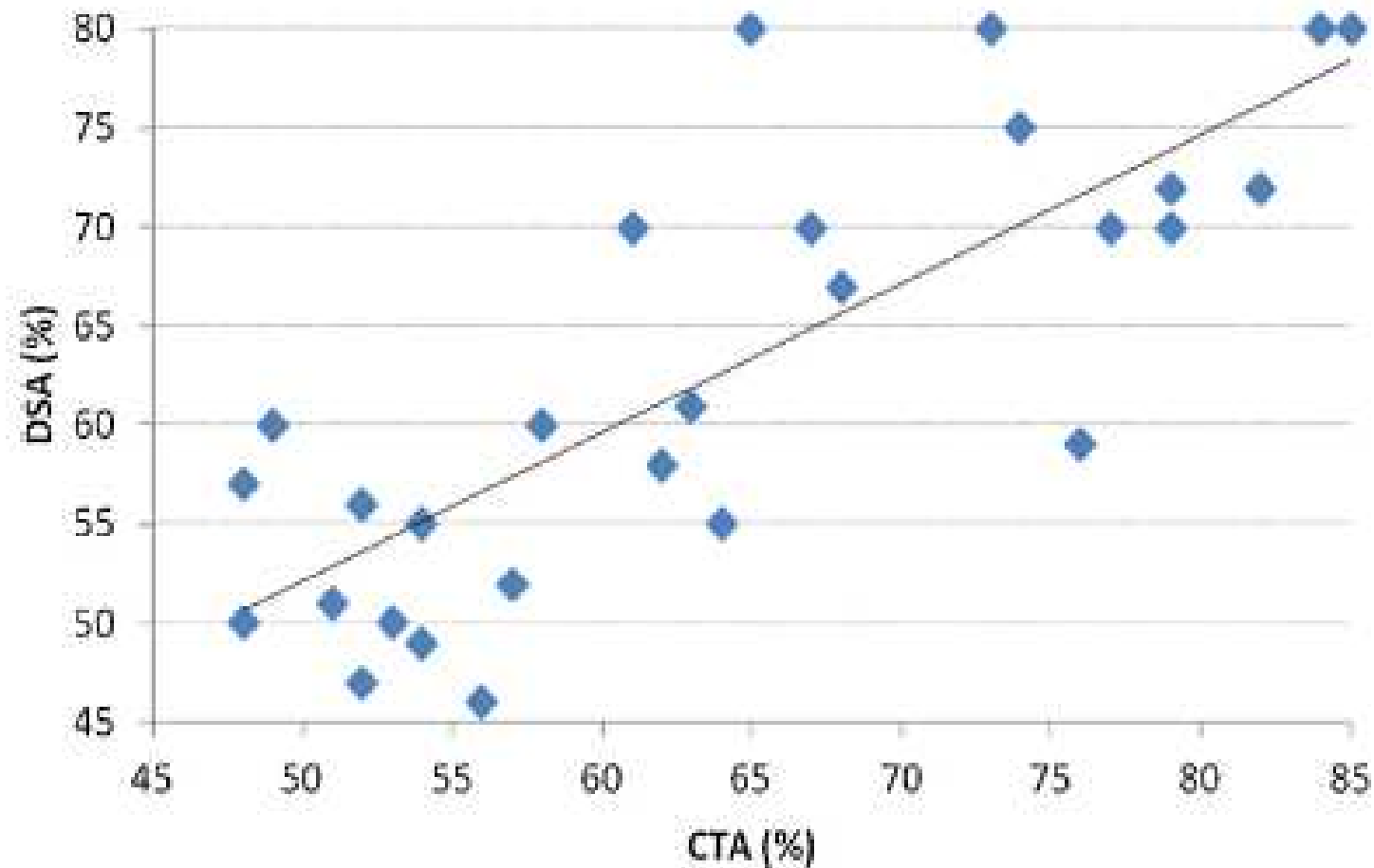


Figure 3 Correlation of CT angiography and digital subtraction angiography results for vertebral artery stenoses $\geq 50\%$. Graph is showing a clear linear relationship between results by both methods.

Discussion

- Vertebral artery stenosis are chronically underdiagnosed
 - Difficulties in their non-invasive imaging
 - Frequent negligence of non-specific clinical vertebrobasilar symptoms
- Other studies report 94% sensitivity and 88% specificity of CTA for VA stenosis 50—99%

Mikiashvili SZh, Pronin IN, Metelkina LP. Spiral computedtomographic angiography in the diagnosis of vertebral

Discussion

- Gold standard DSA could be replaced by CTA, while using CDS as the first line screening
- For moderate and severe VA stenosis
- Spare patients the risk of DSA, reserved for persons with an intended endovascular intervention

Yield of CT Angiography and Contrast-Enhanced MR Imaging in Patients with Dizziness

- The differential diagnosis for dizziness(vertigo)
- That CNS and cerebrovascular causes are excluded
- ◆ No consensus when imaging may or may not be appropriate
- ◆ Which specific imaging test should be obtained.

From the Departments of Radiology and Otolaryngology
University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania

Table 1: Patient demographics and clinical characteristics

	CT Angiography	Contrast-Enhanced MR Imaging, Brain	Contrast-Enhanced MR Imaging, IAC	Total
No. of patients	228	304	266	798
No. of males (%)	106 (47)	115 (38)	98 (37)	319 (40)
Age (yr) (mean) (range)	56 (19–90)	55 (15–90)	54 (6–93)	55 (6–93)
Emergency setting (%)	191 (84)	63 (21)	3 (1)	257 (32)
Diagnostic efficacy	5 (2.2%)	4 (1.3%)	4 (1.5%)	13 (1.6%)
Therapeutic efficacy	3 (1.3%)	2 (0.7%)	3 (1.1%)	8 (1.0%)

Table 2: Ordering clinicians by specialty

	CT Angiography (%)	Contrast-Enhanced MR Imaging, Brain (%)	Contrast-Enhanced MR Imaging, IAC (%)	Total (%)
Otolaryngology	0 (0%)	35 (12%)	158 (59%)	193 (24%)
Neurology	23 (10%)	41 (13%)	31 (12%)	95 (12%)
Internal medicine/primary care specialties	13 (6%)	137 (45%)	68 (26%)	218 (27%)
Emergency department	191 (84%)	63 (21%)	3 (1%)	257 (32%)
Neurosurgery	1 (0.4%)	8 (3%)	3 (1%)	12 (2%)
Other ^a	0 (0%)	20 (7%)	3 (1%)	23 (3%)

When imaging?

- Focal neurologic symptoms and/or sign
- Known vascular abnormality, prior posterior fossa ischemic event, or posterior fossa mass
- **Dizziness with 3 thrombotic stroke risk factors**
 - **CDS, CTA**
 - **MRA**
 - **DSA**
- Routine use of imaging in the evaluation of the patient with uncomplicated dizziness cannot be recommended

A blue-tinted photograph of a surgical team in an operating room. The image shows several surgeons in white scrubs and masks, focused on a procedure. The lighting is bright and clinical. The text "THANK YOU FOR YOUR ATTENTION" is overlaid in white, bold, sans-serif font in the upper center of the image.

THANK YOU FOR YOUR ATTENTION