E-learn Computed Tomographic Angiography: A Proposed Educational Tool for Computed Tomographic Angiography in Acute Stroke

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Background: Computed tomographic angiography (CTA) is widely available in emergency rooms to assess acute stroke patients. To standardize readings and educate new readers, we developed a 3-step e-learning tool based on the test-teach-retest methodology in 2 acute stroke scenarios: vascular occlusion and "spot sign" in acute intracerebral hemorrhage. We hypothesized that an e-learning program enhances reading skills in physicians of varying experience. *Methods:* We developed an HTML-based program with a teaching segment and 2 matching test segments. Tests were taken before and after the teaching segment; the test size was 40% of the teaching segment size. We assessed diagnostic accuracy and readers' confidence. Results were compared using the Wilcoxon rank sum test. *Results:* Four neurologic consultants and four radiologic residents completed the program. The vascular occlusion teaching segment increased diagnostic accuracy from 42% to 68% ($P = .005$). The neurologic consultants showed significant progress, with average scores of 50% versus 75% ($P = .027$). The radiologic residents showed trend with progress, with average scores of 33% versus 60% ($P = .081$). The entire group detected spot sign correctly 69% before versus 92% after teaching ($P = .009$) and reported a median self-perceived diagnostic certainty of 50% versus 75% ($P = .030$). Self-perceived diagnostic certainty revealed no significant increase for vascular occlusion. *Conclusions:* The e-learning program is a useful educational tool for users of varying experience, and it enhances diagnostic confidence. **Key Words:** Computed tomographic angiography—e-learning—spot sign—vascular occlusion.

Acute stroke management relies on rapid, accurate diagnosis, because thrombolytic therapy or thrombectomy are time sensitive. Widely accessible standardized techniques and unequivocal diagnostic criteria support reliable treatment decisions.[1,2] A learning curve of processing and interpreting computed tomographic angiography (CTA) has been suggested, calling for novel tools to bridge this gap.[3] The intent to disseminate neuroimaging expertise and the growing availability of user-friendly imaging software[4] prompted us to develop an e-learning tool for systematic training. Shareware limits costs and standards for shareable content as The Sharable Content Object Reference Model (SCORM)[5] and Aviation Industry Computer-Based Training Commitee (AICC)[6] allow for the integration of text, images, videos, and animations. E-learning programs can be applied locally or as web-based educational databases like MIRC[7] or Eurorad,[8] which are operated by the Radiological Societies of North America and Europe, respectively. Similarly, dedicated e-learning programs may enhance enrollment and patient stratification into stroke trials.

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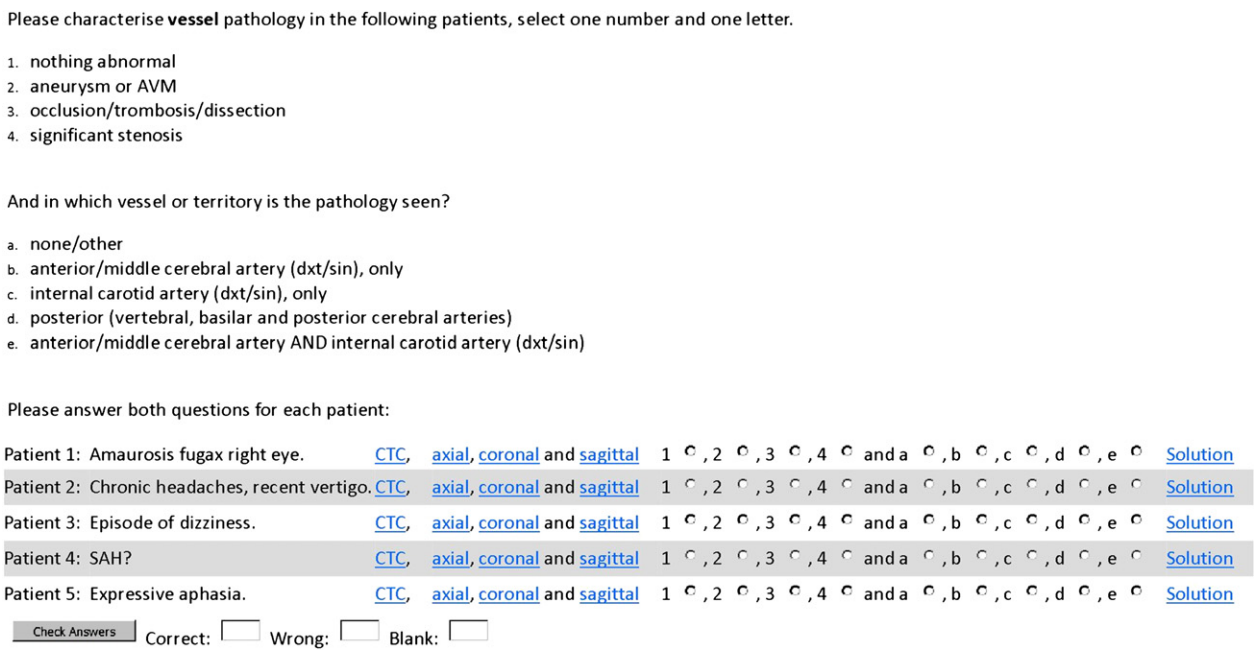
The effectiveness of e-learning depends on carefully constructed content, self-directed learning, and interactive presentation,[9-11] and has been shown upon testing to yield the same improvement in knowledge as standard classroom teaching courses.[10,12]

We intended to validate a well-defined concept for a radiologic image–based e-learning series, including a prelearning test, a teaching segment, and a postlearning assessment. Matching test series allow comparison of knowledge before and after the teaching session, while the concept's flexibility allows for the presentation of any radiologic topic.

Methods

We developed an e-learning program with the aforementioned test-teach-retest methodology and tested it in 2 groups of volunteers. Our hospital's acute stroke team is comprised of neurologic consultants and senior radiologic residents. We tested neurologic consultants and junior radiologic residents with experience in CTA technique but not in acute stroke assessment. Images were obtained from Copenhagen University Hospital Bispebjerg between 2008 and 2010 during thrombolysis assessment within 3 hours after symptom onset using standard protocols and were retrieved from the PACS system (approved by the Danish Data Protection agency; file no. 2010-41-4266). Cases entailed noncontrast CT cerebrum (CTC) and reformatted 10-mm × 2.5-mm spaced maximum intensity projections (MIP) CTA images in axial, coronal, and sagittal planes in bone window (W2000-2500, L400-500) and spot window (W200, L110).[13] In the acute stroke setting, axial source and MIP images are evaluated together. MIP images are particularly useful for small vessel evaluation[14-17]; here we used MIP images only to limit data download and as we deemed them sufficient to teach pathology recognition. All images were reviewed for conflicting pathology by an experienced consultant radiologist unaware of the study hypothesis. Cases of vascular occlusion included short patient stories determining the affected cerebral hemisphere and were reviewed by a senior consultant vascular neurologist.

The e-learning program consisted of 2 matching test segments and a teaching segment applied in the test-teach-retest sequence. We chose 2 topics: the detection of vascular occlusions in acute stroke and the "spot sign."[13,16-21] Our HTML-based program combined text and images structured as a quiz with radio button interface offering mutually exclusive choices without default answers (Fig 1). Oral and written instructions before the test and teaching segments addressed a fixed method for case study, using all available windows and 3 planes, starting with the axial plane and assessing 1 vessel at a time starting with the posterior territory followed by the carotids and finally the Circle of Willis and its branches, and the replication of this method on the coronal and sagittal planes. Candidate lesions were to be verified in at least 2 planes. Teaching instructions explained potential pitfalls, and annotated key images explained solutions (Figs 2-4) in the teaching segment. Case time allowance was 5 minutes for vascular occlusion and 2 minutes for spot sign, recreating the clinical situation. Technical recommendations included a minimum screen resolution of 1024 × 768 pixels and dampened ambient lighting as in a family living room (approximately 50 lux).[22] The vascular occlusion series focused on occlusions but included other common vascular pathologies. A correct answer required correct choices of both pathology


Please characterise **vessel** pathology in the following patients, select one number and one letter.

1. nothing abnormal
2. aneurysm or AVM
3. occlusion/trombosis/dissection
4. significant stenosis

And in which vessel or territory is the pathology seen?

a. none/other
b. anterior/middle cerebral artery (dxt/sin), only
c. internal carotid artery (dxt/sin), only
d. posterior (vertebral, basilar and posterior cerebral arteries)
e. anterior/middle cerebral artery AND internal carotid artery (dxt/sin)

Please answer both questions for each patient:

Patient 1: Amaurosis fugax right eye.	CTC,	axial, coronal and sagittal	1 ○ ,2 ○ ,3 ○ ,4 ○ and a ○ ,b ○ ,c ○ ,d ○ ,e ○		Solution
Patient 2: Chronic headaches, recent vertigo.	CTC,	axial, coronal and sagittal	1 ○ ,2 ○ ,3 ○ ,4 ○ and a ○ ,b ○ ,c ○ ,d ○ ,e ○		Solution
Patient 3: Episode of dizziness.	CTC,	axial, coronal and sagittal	1 ○ ,2 ○ ,3 ○ ,4 ○ and a ○ ,b ○ ,c ○ ,d ○ ,e ○		Solution
Patient 4: SAH?	CTC,	axial, coronal and sagittal	1 ○ ,2 ○ ,3 ○ ,4 ○ and a ○ ,b ○ ,c ○ ,d ○ ,e ○		Solution
Patient 5: Expressive aphasia.	CTC,	axial, coronal and sagittal	1 ○ ,2 ○ ,3 ○ ,4 ○ and a ○ ,b ○ ,c ○ ,d ○ ,e ○		Solution

Check Answers Correct: Wrong: Blank:

Figure 1. *Teaching page example from the vascular occlusion series with choices and radio button interface.*