Medical Error Reduction in Emergency Medicine by Internet-Based Head CT Training

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Introduction

The advent of thrombolytic therapy heralded a potentially substantial benefit for patients, as well as a potentially terrible hazard from administration of TPA to patients with contraindications to therapy. The promised benefit has largely failed to materialize, with few patients being treated with TPA and outcomes failing to match those in the widely publicized NINDS trial.[1, 2, 3, 4, 5] In addition to patient education to encourage earlier presentation following onset of stroke symptoms, two important events must occur to improve appropriate TPA administration and outcomes. Head CT must be rapidly and accurately interpreted, so that interpretation does not pose a substantial delay within the three hour treatment window, and contraindications to TPA on CT scan must be correctly recognized by the interpreting physician.

Emergency physicians are the first line of interpretation for head CT. Many hospitals do not have in-house overnight radiology services, and emergency physicians perform the initial interpretation of images in over 50% of weekday cases in some settings. Interpretation times by radiologists often exceed four hours.[6, 7] Although teleradiology may ultimately improve the speed of interpretation, current studies suggest that teleradiology for head CT requires up to 40 minutes.[5] Although 46% of patients arrive within three hours of symptoms onset,[8] median time delays from ED arrival until CT scan completion are 1.1 hours – ***not including time for CT interpretation***.[9] A National Institute of Neurological Disorders and Stroke advisory committee has suggested as standards 25 minutes to initiation of CT and 45 minutes to interpretation.[10]

Prior studies of emergency physicians show less accurate interpretation of head CT when compared with neurologists and neuroradiologists,[11,12,13] although the clinical significance is uncertain. Emergency physicians poorly identify large visible ischemic strokes which contraindicate thrombolytic therapy.[14] Significant deficiencies also exist in physician knowledge of contraindications to TPA administration.[15] Emergency medicine residents have been shown to make substantial and sustained improvements in head CT interpretation after a brief training intervention, but they remain poor in their ability to recognize ischemic infarct.[16] Prior studies have focused on live training exercises, leaving uncertain the reproducibility of their findings.

Our goal is to establish the baseline ability of emergency medicine residents to identify a range of pathology on head CT with direct influence on management decisions such as thrombolytic therapy. We will then measure the immediate effect of a brief educational intervention on these abilities, as well as re-testing resident performance after three months to determine retention. We will utilize an internet-based training module, as such modules are fully reproducible and have been shown to yield similar educational benefits to live training.[17] Following the study, our validated modules will be available to residency programs to document competency in head CT interpretation for ischemic stroke.

Purpose of the study

The purposes of our study are:

1) to measure the baseline accuracy of emergency medicine residents in interpreting abnormalities on head CT which may alter or contraindicate thrombolytic therapy, including subarachnoid hemorrhage, intraparenchymal hemorrhage, and infarction

2) to measure the immediate and sustained effect of brief interactive computer-based training exercises on accuracy of CT interpretation and administration of thrombolytic therapy

Our null hypothesis is that internet-based training will *not* reduce error rates immediately or in a sustained fashion.

We will design evidence-based, brief training exercises in CT interpretation for subarachnoid hemorrhage, intraparenchymal hemorrhage, and infarction. We propose to test the accuracy of emergency medicine residents at various levels of training immediately before, immediately after, and three months after completion of these brief training exercises.

Design and procedures

Subjects will be emergency medicine residents in training in the United States. Subjects will be randomized in blocks by training program to participate in one of the three "treatment" modules described above or a "placebo" training module unrelated to head CT interpretation. All subjects will participate in a pre-test of the specified pathology, a teaching module specific to that pathology or a placebo module, an immediate post-test of the specified pathology, and a delayed post-test three months later to assess retention of learning and error rates.

An individual's participation is estimated to last 60 minutes for the pre-test, 60 minutes for the training exercise, and 60 minutes for the post-tests. The test items will have an imposed two minute time limit per item, to simulate real world emergency department conditions. Subjects may proceed at their own pace on the teaching module, with their time recorded as a component of the study outcome.

Test items will be complete head CTs drawn from a research archive maintained by EMPACS, a nonprofit organization established by the principal investigator (www.empacs.org). Test CTs will be matched in difficulty by consensus of a panel of expert reviewers. CTs will be viewed on a PACS-like interface, emulating emergency department conditions.

Content

Content will be directed specifically at CT findings which may alter or altogether contraindicate thrombolytic therapy. The core teaching points for the three selected abnormalities are listed below.

1. Cerebral Infarction

- Acute infarction can be recognized by the presence of
    - Hypodensity[18]
    - Loss of grey-white matter demarcation[18]
    - Edema with effacement of sulci or Sylvian fissure[18]
    - Hyperdense MCA sign[19, 20]
- Infarcts greater than 1/3 of the MCA territory contraindicate systemic TPA[21]

2. Intraparenchymal hemorrhage[22]

- Intraparenchymal hemorrhage can be recognized by the presence of
    - Hyperdensity
    - Local mass effect
    - Surrounding edema
- Intraparenchymal hemorrhage is an absolute contraindication to systemic TPA

3. Subarachnoid hemorrhage[22]

- Subarachnoid hemorrhage can be recognized by the presence of hyperdensity
- Common locations for subarchnoid hemorrhage are
    - Cortical sulci and interhemispheric fissure
    - Ventricles
    - Cisterns, including interpeduncular fossa and suprasellar cistern
- Subarachnoid hemorrhage is an absolute contraindication to systemic TPA

Content will be depicted through interactive modules focusing on

- **What** – the appearance of the abnormality
- **Where** – the common locations of the abnormality
- **Why** – the importance of the finding in patient management

The modules will require the user to interact with the slide set. Correct identification of abnormalities and management implications will allow the user to move forward in the tutorial. Incorrect responses will direct the user to remedial sections of the tutorial, allowing advancement only when the material has been mastered.

A sample screenshot from the EMPACS database is shown in **figure 1**. Modules will employ a similar interface. Test items will be similar to that shown in **figure 2**.

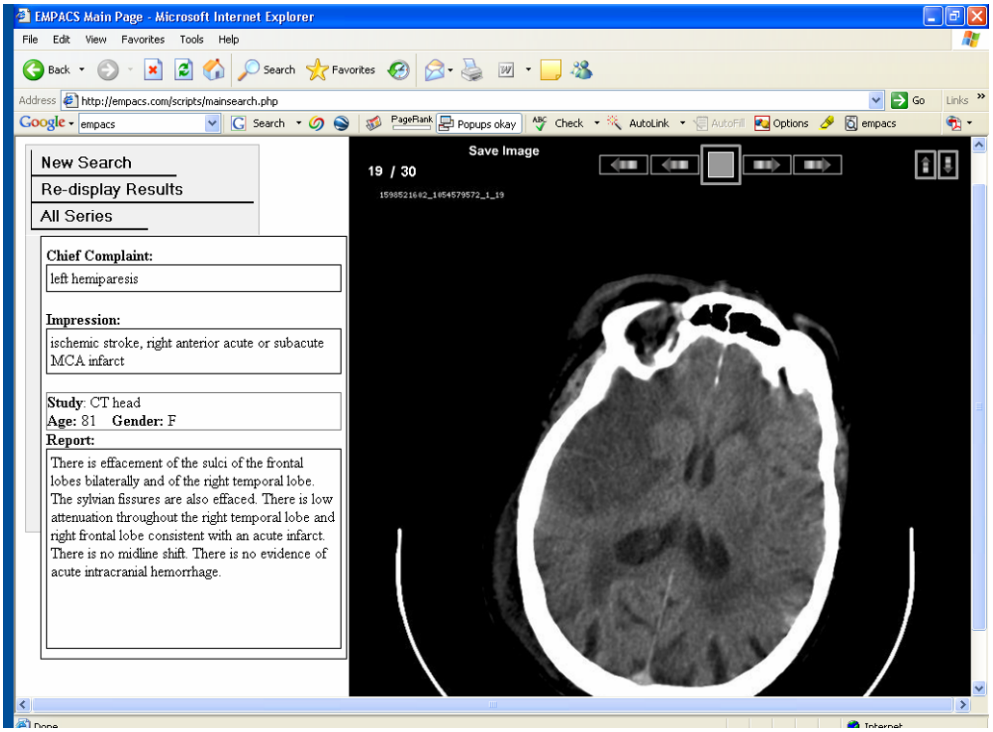

Figure 1. Screenshot from EMPACS database. An extensive library of head CTs will be drawn upon for the teaching and testing modules.

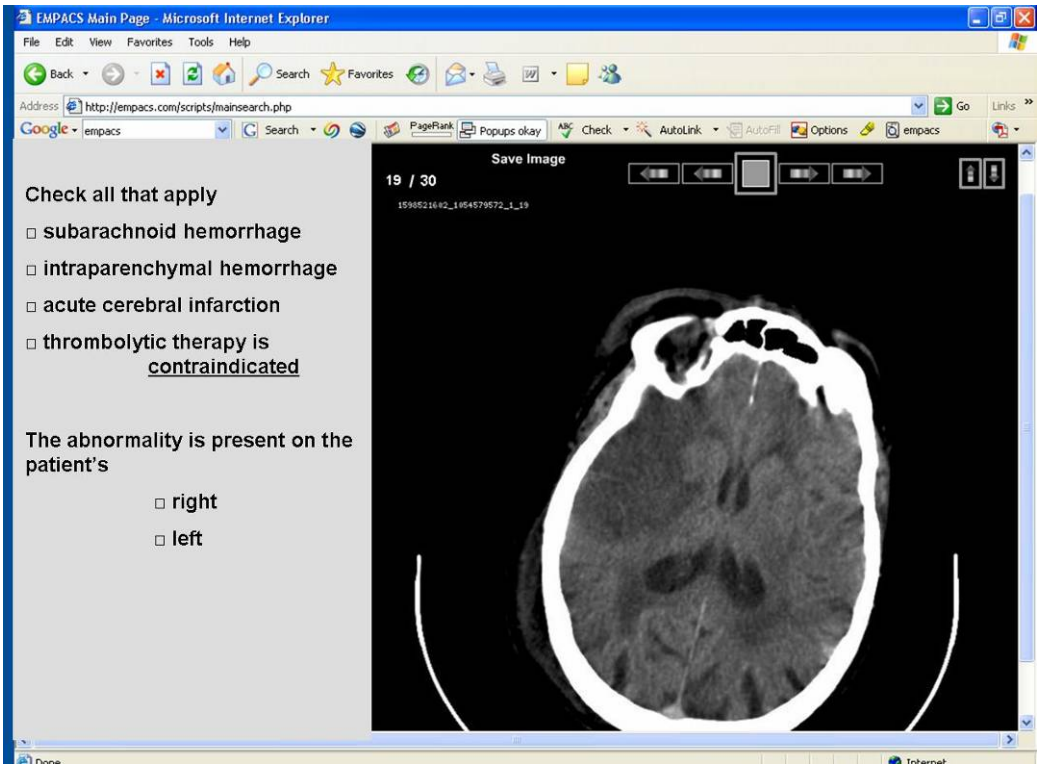

Figure 2. Example test item.

Budget

Identification of CT scans representing selected pathology……	**$5000**
Grading of CT scans for difficulty, with interobserver agreement measurements..	**$1000**
Selection of CT scans for test items……..…….	**$1000**
Development of interactive teaching modules……	**$5000**
Website interactive form development……	**$1000**
Deployment/ subject recruitment costs……..…….	**$1000**
Server space/design software costs…….……	**$1000**
Programmer costs……...…….	**$5000**
Statistician costs……...……...	**$5000**
Total…….	**$25000**

Timeline

IRB application/approval……...	4/2006
Identification of CT scans representing selected pathology…….....	5/2006
Grading of CT scans for difficulty, with inter-observer agreement……... measurements	5/2006-6/2006
Selection of CT scans for test items……..……	5/2006-6/2006
Development of interactive teaching modules……..	5/2006-6/2006
Website interactive form development……..	5/2006-6/2006
Deployment/ subject recruitment……..…….	7/2006
Data collection……...	7/2006-10/2006
Data analysis……...……...	10/2006
Manuscript preparation……...……...	10/2006

References

[1] Katzan IL, Hammer MD, Hixson ED, Furlan AJ, Abou-Chebl A, Nadzam DM; Cleveland Clinic Health System Stroke Quality Improvement Team. Utilization of intravenous tissue plasminogen activator for acute ischemic stroke. Arch Neurol. 2004 Mar;61(3):346-50.

[2] Bravata DM, Kim N, Concato J, Krumholz HM, Brass LM. Thrombolysis for acute stroke in routine clinical practice. Arch Intern Med. 2002 Sep 23;162(17):1994-2001.

[3] Dick AP, Straka J. IV tPA for Acute Ischemic Stroke: Results of the First 101 Patients in a Community Practice. Neurologist. 2005 Sep;11(5):305-8.

[4] Katzan IL, Furlan AJ, Lloyd LE, Frank JI, Harper DL, Hinchey JA, Hammel JP, Qu A, Sila CA. Use of tissue-type plasminogen activator for acute ischemic stroke: the Cleveland area experience. JAMA. 2000 Mar 1;283(9):1151-8.

[5] Kalyanpur A, Weinberg J, Neklesa V, Brink JA, Forman HP. Emergency radiology coverage: technical and clinical feasibility of an international teleradiology model. Emerg Radiol. 2003 Dec;10(3):115-8. Epub 2003 Jul 22.

[6] Saketkhoo DD, Bhargavan M, Sunshine JH, Forman HP. Emergency department image interpretation services at private community hospitals. Radiology. 2004 Apr;231(1):190-7. Epub 2004 Feb 27.

[7] Lowe RA, Abbuhl SB, Baumritter A, Brensinger C, Propert K, Horii S, Kundel H. Radiology services in emergency medicine residency programs: a national survey. Acad Emerg Med. 2002 Jun;9(6):587-94.

[8] Lacy CR, Suh DC, Bueno M, Kostis JB. Delay in presentation and evaluation for acute stroke: Stroke Time Registry for Outcomes Knowledge and Epidemiology (S.T.R.O.K.E.). Stroke. 2001 Jan; 32(1):63-9.

[9]Morris DL, Rosamond W, Madden K, Schultz C, Hamilton S. Prehospital and emergency department delays after acute stroke: the Genentech Stroke Presentation Survey. Stroke. 2000 Nov;31(11):2585-90.

[10] Marler J, Winters Jones P, Emr M, eds. *Proceedings of a National Symposium on Rapid Identification and Treatment of Acute Stroke.* Washington, DC: National Institute of Neurological Disorders and Treatment of Acute Stroke; 1997. Publication No. (NIH) 97-4239.

[11] Schriger DL, Kalafut M, Starkman S, Krueger M, Saver JL. Cranial computed tomography interpretation in acute stroke: physician accuracy in determining eligibility for thrombolytic therapy. JAMA. 1998 Apr 22-29;279(16):1293-7.

[12] Arendts G, Manovel A, and Chai A. Cranial CT interpretation by senior emergency department staff. Australasian Radiology(2003)47, 368–374.

[13] Eng J, Mysko WK, Weller GE, Renard R, Gitlin JN, Bluemke DA, Magid D, Kelen GD, Scott WW Jr. Interpretation of Emergency Department radiographs: a comparison of emergency medicine physicians with radiologists, residents with faculty, and film with digital display. AJR Am J Roentgenol. 2000 Nov;175(5):1233-8.

[14] Kalafut MA, Schriger DL, Saver JL, Starkman S. Detection of early CT signs of >1/3 middle cerebral artery infarctions : interrater reliability and sensitivity of CT interpretation by physicians involved in acute stroke care. Stroke. 2000 Jul;31(7):1667-71.

[15] Schriger D, Kalafut M, Starkman S, et al: Cranial Computed Tomography Interpretation in Acute Stroke. Physician Accuracy in Determining Eligibility for Thrombolytic Therapy. JAMA 1998 Apr 279(16): 1293-1297.

[16] Perron AD, Huff JS, Ullrich CG, Heafner MD, Kline JA. A multicenter study to improve emergency medicine residents' recognition of intracranial emergencies on computed tomography. Ann Emerg Med. 1998 Nov; 32(5):554-62.

[17] Fordis M, King JE, Ballantyne CM, Jones PH, Schneider KH, Spann SJ, Greenberg SB, Greisinger AJ. Comparison of the instructional efficacy of Internet-based CME with live interactive CME workshops: a randomized controlled trial. JAMA. 2005 Sep 7;294(9):1043-51.

[18] Grotta JC, Chiu D, Lu M, Patel S, Levine SR, Tilley BC, Brott TG, Haley EC Jr, Lyden PD, Kothari R, Frankel M, Lewandowski CA, Libman R, Kwiatkowski T, Broderick JP, Marler JR, Corrigan J, Huff S, Mitsias P, Talati S, Tanne D. Agreement and variability in the interpretation of early CT changes in stroke patients qualifying for intravenous rtPA therapy. Stroke. 1999 Aug;30(8):1528-33.

[19] Berge E, Nakstad PH, Sandset PM; HAEST Study Group. Large middle cerebral artery infarctions and the hyperdense middle cerebral artery sign in patients with atrial fibrillation. Acta Radiol. 2001 May;42(3):261-8.

[20] Philip A. Barber, MRCP(UK); Andrew M. Demchuk, FRCPC; Mark E. Hudon, FRCPC; J.H. Warwick Pexman, FRCPC; Michael D. Hill, FRCPC; Alastair M. Buchan, FRCP(Edin). Hyperdense Sylvian Fissure MCA "Dot" Sign, A CT Marker of Acute Ischemia. Stroke. 2001;32:84.

[21] von Kummer R, Allen KL, Holle R, Bozzao L, Bastianello S, Manelfe C, Bluhmki E, Ringleb P, Meier DH, Hacke W. Acute stroke: usefulness of early CT findings before thrombolytic therapy. Radiology. 1997 Nov;205(2):327-33.

[22] Hoggard N, Wilkinson ID, Paley MN, Griffiths PD. Imaging of haemorrhagic stroke. Clin Radiol. 2002 Nov;57(11):957-68.