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CTA in acute stroke: short intensive training intervention is highly effective in improving radiologists' performance.

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Introduction

Stroke is the 2nd commonest cause of death worldwide affecting 6.7 million patients and representing 11.9% of all deaths [1]. In the UK, stroke is the largest cause of disability in adults; half of all stroke survivors are dependent on carers with activities of daily living [2]. Until recently, intravenous thrombolysis (IVT) was the only available hyper-acute treatment, but mechanical thrombectomy is now a proven therapeutic option for patients presenting with acute ischaemic stroke caused by proximal large artery occlusion (LAO). There have been 8 recently published positive mechanical thrombectomy trials [3–10]. NICE (National Institute for Health and Care Excellence) has approved thrombectomy for use in the NHS (National Health Service) [11]. Proximal LAO accounts for ~40% of ischaemic strokes [12] and this group of stroke patients present with the biggest deficits (so often present quickly) but respond least well to IVT with a disproportionately high disability burden as a result. [13]

Fast and accurate assessment of patients potentially suitable for acute interventional management is critical to offer the best treatment. In our regional teaching hospitals out of hours CT/CTA scans are provisionally reported by a general radiology (specialist) trainee. The supervising on call neuroradiology consultant, although available for giving a second opinion at any time, will review all scans and document any disparities within 1-12h.

Traditional preparation for starting Radiology on-call consists in the usage of teaching collections, lectures and rotations into the different radiological specialties. In a traditional teaching file only key images are provided, which allows many pathologies to be presented in a limited time. Simulation training enables users to experience a more real life experience of reporting cases and using different visualisation tools (e.g. windowing, reconstructions) to accurately interpret the imaging examinations. This method of training has become widely used in interventional specialties, including interventional radiology. With digital imaging now ubiquitous, it is much easier to implement digital simulation teaching resources into diagnostic radiology. The opportunity to participate in training within a safe environment where trainees can review and report entire examinations promotes confidence, especially at the beginning of on-call commitments.

The purpose of this study was to develop simulated radiology training for reviewing CTAs of patients presenting with hyperacute ischaemic stroke. A validated case archive (VCA) was used together with a few short presentations on relevant anatomy, CTA technique and CTA reporting tips to create a full day training course. We then reviewed the reports of the radiology trainees pre and post CTA training day to assess whether it had impacted on their reporting performance and confidence.

Materials and Methods

Validated Case Archive Development

As a first step, the scans of 364 patients presenting over a period of seven months with clinical details of acute stroke symptoms were reviewed. From these, all CTA scans were reviewed and assessed for their image quality. Fifty cases were subsequently selected for the development of a VCA. The intention was to have a mixture of normal scans, which would be used to practice and develop a methodology of assessing these examinations, a few cases with normal anatomical variants, which are important to recognise and finally a mix of stroke and non-stroke pathologies that are typically encountered. Seven of the VCA cases were normal with common normal anatomical variants. The other 43 scans had significant primary vascular pathology responsible for the patient's symptoms and six scans were included because they also had secondary incidental but significant findings. These 50 CTA cases were validated by three neuroradiologists (2 consultants, 1 fellow) who reviewed all images and recorded all the findings. Two neuroradiologists reviewed any discrepancies and a consensus was obtained to create a reference standard based on a combination of the consensus imaging findings, clinical findings and clinical course plus evolution on any subsequent imaging.

After obtaining permission from the Trust Caldicott guardian, the anonymised CT brain/CTA image DICOM data sets were exported to Osirix [14]. In order to allow the reporting experience to be as close to real life as possible, the (anonymised) presenting clinical details and key past medical history of each patient were noted by transcription from electronic patient records and by obtaining patient's notes in selected cases.

A report type document was attached to every single examination in Osirix. This report included the clinical presentation along with any relevant medical history, the reference standard scan findings noting findings both on the unenhanced brain and the CTA sequences, and finally any acute treatment given to the patient as well as the medium-term clinical outcome (3-6 months).

Osirix MacLab

The training days were delivered in a purpose built radiology training centre which has 12 Apple 27" retina iMacs each running Osirix 64bit [14]. This software has the capability to handle large datasets, it allows the user to view and manipulate DICOM files and it has all the standard PACS functions built in; including more complex functions such as multiplanar reformats, volume rendering and vessel analysis (Figure 1 and Figure 2). Video tutorials on how to use Osirix and its capabilities are freely available online at http://www.osirix-ukusergroup.org/video-tutorials.

The networked set-up allows for lectures and cases to be displayed on each individual workstation and on the large wall mounted monitor. This allows trainers to demonstrate subtle and complex findings to the trainees.

Radiology Trainee Participation

A full training day consisting of three 30 minutes lectures followed by simulation training was developed. The lectures covered the importance of acute stroke imaging including a review of recent evidence for imaging in acute stroke, the technical requirements, neurovascular anatomy and a methodological approach of how to interpret and report these scans. The remainder of the day, trainees worked at their own pace through suggested VCA cases before reviewing them with the facilitator (neuroradiology fellow &/or consultant). Trainees evaluated 15 to 20 VCA cases during the course of the day.

Between September 2015 to September 2016, all radiology trainees performing on-call duty at our institution attended this course. In total 44 trainees attended 1 of 4 training days. The training days were organised according to neuroradiologists' availability and typically two trainers delivered the programme on each day.

Assessment of Performance

Radiology trainees reports pre and post CTA training were reviewed and assessed objectively for amendments to the original provisional reports. The amendments added by consultant neuroradiologists were then categorised as major or minor.

A major discrepancy (error) was defined as a significant finding which if mentioned on the initial report definitely/probably would impact on the patient's management such as: acute infarcts, intracranial haemorrhage, large vessel occlusion, dissection and significant atheromatous disease (e.g. >70% ICA stenosis).

A minor discrepancy was defined as a not clinically significant reporting error, which would definitely/probably not have any impact on the acute management for the patient e.g.: old strokes, less than 50% internal carotid artery (ICA) atheroma and/or stenosis, other incidental findings such as small aneurysms, small meningioma, thoracic lymph nodes, etc.

Figures 3-4 demonstrate examples of both major and minor discrepancies.

Data collected included the date of scan, patient ID, age, sex, provisionally reporting trainee, year of training, time of report, CTA training status (pre/post), any neuroradiologist amendments and any other relevant report details. We performed simple logistic regression analyses using IBM SPSS Statistics, version 23, Armonk, NY: IBM Corp. to assess the pre and post training error rates, including total, minor and major error rates.

Results

Forty-eight radiology trainees had their reports reviewed retrospectively over a period of one year. As the CTA training was delivered over a period of time (4 sessions) and typically trainees rotate through different hospitals, we assessed reports from 21 trainees who had attended the CTA training and 27 trainees who had not. Six of the 48 registrars had both pre and post CTA training reports and this group was analysed as a subset. 252 reports were reviewed in total - 147 of them being done pre- and 105 done post CTA training.

Examining trainees' seniority, slightly more in the pre CTA training group of reports (58% vs 51%) were by more experienced trainees, year 4 and 5. This is because CTA training was preferentially first delivered to the most junior registrars (year 2 and 3) who are on-call.

In the control (pre CTA training) group 57 out of 147 reports on CT/CTA examinations were amended due to a perceptual/reporting discrepancy (error), a total discrepancy rate of 39%. In the intervention group (post CTA training) 36 out of 105 reports were amended, a total discrepancy rate of 34%.

In the control group there were 17/147 reports on CT/CTA examinations with major discrepancies, a rate of 12%. In the intervention group, there were 4/105 major discrepancies, a rate of 4%.

In terms of minor discrepancies, the control group reports had 40/147 discrepancies, a minor discrepancy rate of 27%; the intervention group reports had 32 minor discrepancies out of 105 examinations reviewed, a minor error rate of 30%.

The improvement in total errors was not statistically significant; p=0.467, odds ratio (OR) = 1.214, 95% CI = 0.720 to 2.046. The reduction in the major discrepancy rate was statistically significant, p=0.037, OR = 3.302, 95% CI = 1.078 to 10.118. The small increase in minor errors was not significant and simple logistic regression demonstrated p=0.572, OR = 0.853, 95% CI = 0.491 to 1.481.

Subset analysis on 6 trainees with both pre and post CTA training reports was performed, who in total reported 69 examinations (Figure 5). Thirty-three reports were done pre CTA training and 36 reports post training. The maximum time lapse between training and the assessed on-call reports were between four to six months. The total discrepancy rate pre-CTA training was 48% (16/33) which improved to 25% (9/36) post training; p=0.046, OR = 2.824, 95% CI = 1.021 to 7.810. The major discrepancy rate substantially improved from 15% (5/33) to 0% (0/36). Logistic regression was inappropriate for analysing major discrepancy rate because zero cases had major discrepancies post-training. Similarly, this prevented the calculation of an OR. A Fisher's exact test was used to calculate significance, p=0.021. The minor discrepancy in this trainee subset was 33% (11/33) pre training, improving to 25% (9/36) post CTA training, a non-statistically significant improvement, p=0.447, OR = 1.5, 95% CI = 0.527 to 4.267.

Overall, 73% of trainees reported feeling more confident with reporting CTAs after attending the VCA training.

Discussion

The rate of major discrepancies in our study is in line with professional society rates of 3-30% [15]. We have found that registrar attendance to a focussed 1-day stroke CTA course built around a VCA to provide simulation training significantly decreased the rate of major errors from 12% to 4%, which is within the lower range of accepted radiology discrepancy rates. Similarly, the subset of registrars which attended our course and had both pre and post CTA training reports, improved their major discrepancy rate from 15% to 0%. Overall, the CTA training intervention had a significant impact on the major discrepancy rate. This is the most important aspect as these radiology trainee provisional reports are the imaging interpretation that will immediately impact hyperacute stroke patient management. It is important for radiology trainees to have adequate experience and a good method of assessing stroke CT examinations if they are to safely, accurately and expeditiously report acute on-call stroke scans. The time pressure in hyperacute stroke management dictates that considerable weight is given to the initial CT/CTA report, particularly out of hours.

Ultimately this training has led to improved acute identification of patients who may benefit from thrombectomy.

This intervention allows the registrars to have an educational tool that closely mimics on-call in a safe learning environment with review of entire CT/CTA study and ability to manipulate images by windowing, zooming etc. as they would in the on-call setting. This has the advantage of allowing trainees to independently evaluate the scan and find the relevant pathology rather than just pointing to them the findings of interest. This is more challenging and every trainee has the opportunity to assess and go through scans at their own time, not just observing reporting. In terms of both building confidence and more objectively in diagnostic performance - prospectively assessed by discrepancy rates- the intervention has proved successful. The feedback from the radiology trainees was excellent and an online resource to complement the training day has been developed. The CTA interpretation intervention has also been used for other groups including consultant radiologists, radiographers and stroke physicians. Based on published experience in studies examining stroke imaging interpretation we would not expect the training benefit to be limited to radiologists (whatever their experience) but also to extend to stroke physicians, neurologists etc.[16] This approach could be used to train general consultant radiologists working in DGHs or working for outsourcing companies and a similar model of assessment could be implemented to assess discrepancies.

One of the limitations of this study is the relatively small study size. Another is the staggered training period of one year due to the off-site location of the training facility and the trainee and neuroradiology staff availability. Due to this and because trainees move in and out of the on-call rota on rotation to other hospitals a group comparison was performed.

A previous large study on resident on-call discrepancy rates has identified neuroradiologic head CT studies as having the highest overall major discrepancy rates 7. The same study showed that focussed teaching on the specific topics that had the largest number of discrepant reports, led to a statistically significant improvement in subsequent trainee reports [17]. Similarly, in our study we have shown that focused stroke CTA training significantly improved major discrepancy rate. The next question is whether one session is enough, or whether refresher sessions need to be organised to keep up this skill in radiologists who do not routinely report stroke CTA examinations.

A stroke CTA training intervention using a validated case archive within a simulation facility has proved highly successful in one English region. The reporting accuracy of general radiology trainees with a range of experience improved. Most importantly, the major discrepancy rate significantly decreased. We feel that this is a very useful tool in the training of professionals in CTA interpretation for hyperacute stroke symptoms. It indicates that most radiologists undertaking such a learning process likely do not need extensive training to reach acceptable competency levels in stroke CTA (very low major error rate).

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Figures Legend

Figure 1. Osirix user interface. Main window with all the expected menu options at the top, including ROI and Plug-ins, with each one of these having further sub-menus. Under this all the basic study functions are present in a toolbar, including import/export, anonymization, report, search function and these can be customised to your preferences. On the left side the Albums and the Locations as well as any current Activity are shown. The main database window shows the different cases available. Under this, once a case is clicked on, the quick viewer window shows the different sequences available on the left and on the right the selected series can be scrolled through for a quick overview. To open the viewer window, either double click a patient or a series from the quick viewer window.

Figure 2. Osirix viewer. This has a similar interface with the menu bar at the top and the toolbar underneath which has all the expected basic functions like windowing, zooming, measuring and more advanced functions like reconstructions and vessel analysis. The toolbar can be customised and further more advanced plugins can also be downloaded and added to Osirix. The scan series are displayed on the left side and once you click on one, this will open in the main viewing window on the right side.

Figure 3. Major error example. An 83 years old lady who presented acutely with left sided neglect, left arm and leg weakness, dysarthria and dysphagia. The provisional report did not identify the low attenuation changes in the right insula (a), the dense M2 vessel on the pre-

contrast scan (b) or the M2 MCA thrombus on the CTA images (c,d). This was classified as a major error.

Figure 4. Minor error example. A 73 years old lady with new right sided acute visual symptoms. No acute findings were present on the scan, but a 3mm right paraopthalmic aneurysm (arrowed) was not identified on the provisional report. This was classified as a minor error.

Figure 5. Discrepancy rates in subset of trainees with reports assessed pre and post CTA training.