Does additional delayed imaging provide valuable unique information in head and neck CT angiography for the evaluation of arterial patency?

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Purpose

To investigate the value of additional delayed imaging obtained as part of a protocol used for the CTA evaluation of head and neck arterial patency.
Methods and Materials

All CT angiograms of the head and neck performed in a consecutive 30 day period were retrospectively identified from our PACS system. The reports of those studies in which delayed imaging was obtained were then reviewed. These reports were separated into two groups. Group 1 consisted of those reports where unique information was identified on delayed imaging and Group 2 consisted of those reports without unique information. Unique information was defined as the presence of vessel patency identified only on the delayed images.

CT angiography was performed on an 8, 16 or 64 slice Lightspeed scanner (GE Healthcare, WI, USA). A typical protocol utilized 120-140 kVp, Smart-mA and SmartPrep methodologies with a scan range from the aortic arch to the skull vertex. Rotation time was 0.4 -0.7 sec with 0.5 pitch, using a 10-20 mm beam width and reconstructing 1.25 mm slices at 0.625 mm centers. 100ml of contrast (Iovue-370, Bracco Diagnostics Inc.) were injected at 3.5 ml/sec, immediately followed by 40 ml of saline injected at 4 ml/sec. The SmartPrep methodology monitored contrast arrival in the ascending aorta and initiated image acquisition from the skull vertex caudally after there was a recorded 50 HU increase. After completion of the initial CTA phase, the second phase of delayed images was performed from the skull vertex, or the Circle of Willis, caudally.

These two data sets were transferred to the 3D reconstruction laboratory where multiplanar (MPR) and Maximum Intensity Projection (MIP) CT angiographic images were generated for review and diagnosis.

We utilized these images and the radiologists' report to evaluate whether or not the delayed images added unique information concerning patency of neck and intracranial vessels.
Results

There were a total of 308 CTAs performed during the review period. Of these, 109 studies included delayed imaging. Six of these 109 studies were excluded from further analysis as they had been performed specifically for the evaluation of major parenchymal hemorrhage. Of the remaining 103 studies, there were 2 in which delayed imaging provided unique information [1.9%]. In case one, the reconstitution of the major divisions of the right MCA were only appreciated on the delayed images. In case two, a hairline lumen was seen on the delayed images. In the remaining cases, there was no new/added information from the delayed images as recorded in the radiology report.

The routine deployment of second phase, delayed image acquisition for the evaluation of cervical and intracranial vasculature has been advocated as a technique for distinguishing between an occluded versus near-occluded internal carotid artery. This retrospective study has demonstrated that the objective value of such delayed image series, when included as an integral part of a routine CT angiography (CTA) protocol, results in added value in fewer than 2% of patients. In the context of a cost benefit evaluation, such a result means that radiologists providing this service should weigh the potential benefits in a very small number of patients against the potential unnecessary radiation burden in a much larger number of patients.

Cases from the study population:

Patient A, Fig. 1-4, is an example of one of the two positive cases in this study. The patient presented to the emergency room with signs and symptoms of acute stroke. Evaluation of the early CTA images demonstrated clot in the right MCA, with poor visualization of MCA branches beyond the occlusion. However, the delayed images better identified the Sylvian branches of the right MCA, presumably by virtue of collateral pathways and retrograde opacification. In this case the delayed transit of contrast through collateral pathways could only be appreciated on the delayed views.

Patient B, Fig. 5-12, is an example where delayed images did not yield improved information over that appreciated from the early CTA series. This patient was imaged to evaluate for patency of the right internal carotid artery. Comparison between the early CTA phase and the delayed imaging demonstrated that the string sign was better visualized on the early images. A likely reason for this is the higher peak concentration of contrast observed on the earlier images during the initial passage of contrast through the vasculature, before re-circulation takes place with its associated contrast dilution. This case exemplifies the findings in the majority of the patients in this study.
Additional cases obtained outside this study:

We present three cases that were not part of the original study group where delayed images were obtained and did identify additional information concerning the vascular status of the patient. Patients C and D were imaged prior to carotid endarterectomy, while patient E was imaged to evaluate the status of intracranial hemorrhage.

**Patient C, Fig. 13-16**, was imaged to evaluate for a hairline residual lumen in the left internal carotid artery, after non-invasive studies were equivocal for residual lumen patency. Delayed images are routinely collected in these pre-surgical patients. The proximal left internal carotid artery (LICA) is clearly visualized on the early images. But the siphon portion of the left internal carotid artery is not opacified on these early images. Review of the delayed images demonstrates reduced opacification of the proximal LICA, with improved opacification of the distal, siphon LICA. The improved visualization of the distal LICA is likely due to a combination of retrograde filling from collateralization via the ophthalmic artery and antegrade filling from very slow flow along the cervical portion of the barely patent LICA.

**Patient D, Fig. 17-24**, was also imaged prior to endarterectomy to evaluate the condition of the left ICA beyond a severe stenosis at the carotid bifurcation. The left ICA demonstrates a "slim" sign by virtue of decreased flow and pressure as a result of the proximal stenosis. In this case, the early image series readily demonstrated the proximal patency of the ICA, but the delayed image series better demonstrated patency in the petrous segment. However, the delayed views also demonstrated almost complete washout of the contralateral, normally perfused, right internal carotid artery. Correct interpretation of this study requires both early and delayed views to identify all the patent vessels.

**Patient E, Fig. 25-27**, was a patient with acute intracranial hemorrhage. In this case, the delayed images demonstrated active extravasation, not appreciated on the early image set. Patients with acute intracranial hemorrhage were excluded from our analysis as our inclusion criteria were specific for evaluation of potential residual lumen vessel patency only.
Fig. 0: Patient A: There is a clot in the M1 segment of the right MCA seen on the early phase of the CTA. Reconstitution of the major divisions of the right MCA beyond the clot was difficult to appreciate on these early phase images.

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**Fig. 0:** Patient A: There is a clot in the M1 segment of the right MCA. Reconstitution of the major divisions of the right MCA was better appreciated on the delayed images obtained 15 seconds after the first phase.

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**Fig. 0:** Patient A: There is a clot in the M1 segment of the right MCA. The reconstitution of the major divisions of the right MCA was difficult to appreciate on this early phase image.
**Fig. 0:** Patient A: There is a clot in the M1 segment of the right MCA. Reconstitution of the major divisions of the right MCA was better appreciated on the delayed images obtained 15 seconds after the first phase.

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**Fig. 0:** Patient B: Critical stenosis in the right internal carotid artery with "string sign" is well demonstrated on the early CTA phase.

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**Fig. 0:** Patient B: Delayed imaging obtained 53 sec after the early phase CTA images. Critical stenosis in the right internal carotid artery with "string sign" is less well demonstrated than on the early phase images.

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Fig. 0: Patient B: Hairline lumen in the right petrous internal carotid artery is well demonstrated in the early CTA phase.

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**Fig. 0:** Patient B: Delayed imaging obtained 53 sec later. Hairline lumen in the right petrous internal carotid artery is not well demonstrated.

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**Fig. 0:** Patient B: Critical stenosis in the proximal right internal carotid artery with "string sign" in the distal ICA is well demonstrated on the MIP images of the early phase.

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**Fig. 0:** Patient B: Critical stenosis in the right proximal internal carotid artery with "string sign" in the distal ICA is not clearly demonstrated on the MIP images of the delayed phase.

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Fig. 0: Patient B: Critical stenosis in the right proximal internal carotid artery with "string sign" in the distal ICA is well demonstrated in the early phase on this curved reformat image.

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**Fig. 0**: Patient B: Critical stenosis in the right proximal internal carotid artery with "string sign" in the distal ICA is difficult to visualize on the MIP images of the delayed phase.

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**Fig. 0:** Patient C: Hairline lumen in the left cervical internal carotid artery is clearly demonstrated on the early CTA phase.

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**Fig. 0:** Patient C: Delayed imaging obtained 86 seconds after the early CTA phase. The hairline lumen in the left cervical internal carotid artery can also be seen but not as clearly as on the early phase images.

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Fig. 0: Patient C: Patency of the siphon portion of left internal carotid is not clearly demonstrated on the early CTA phase images.

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**Fig. 0:** Patient C: The siphon portion of the left internal carotid artery is better demonstrated on the delayed imaging acquired 86 seconds later.

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**Fig. 0:** Patient D: The severe stenosis in the left cervical internal carotid is best seen in the early CTA phase.

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Fig. 0: Patient D: The critical stenosis in the left cervical carotid can be faintly seen on the delayed images obtained 19 seconds after the early phase; visibility is better on the early CTA phase images.

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**Fig. 0**: Patient D: In the early CTA phase, the normal right petrous internal carotid artery is well opacified. The petrous segment of the abnormal left internal carotid artery is only partially opacified.

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**Fig. 0:** Patient D: In the delayed series obtained 19 seconds after the early phase, the normal right petrous internal carotid artery is no longer opacified because contrast has washed out of this normal vessel. However, the petrous segment of the abnormal left internal carotid artery is better opacified on the delayed phase compared to the early CTA phase.

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Fig. 0: Patient D: In the early CTA phase, the distal segment of the abnormal left internal carotid artery is only partially opacified as shown on this MIP image.

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**Fig. 0:** Patient D: In this MIP image of the delay series obtained 19 seconds after the early phase, the distal segment of the abnormal left internal carotid artery is better opacified than seen on the early phase.

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**Fig. 0:** Patient D: The severe stenosis at the left ICA origin with "slim" sign is best seen in the early phase as demonstrated on this MIP image.

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**Fig. 0:** Patient D: While the severe stenosis at the left ICA origin with "slim" sign is seen on the MIP image of the delayed series, it is not seen as well as on the early phase images. This is likely due to dilution effects resulting from recirculation.
**Fig. 0:** Patient E: Non contrast CT demonstrating an acute large right thalamic intraparenchymal hemorrhage with significant intraventricular hemorrhage and mild hydrocephalus.

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**Fig. 0:** Patient E: The early CTA phase does not clearly demonstrate a "spot sign" which would indicate active extravasation.

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**Fig. 0:** Patient E: Delayed phase images obtained 15 seconds after early phase imaging demonstrates two "spot" signs, indicating active extravasation.

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Conclusion

In this retrospective review, additional delayed imaging provided unique information in fewer than 2% of cases. Based on this result, the use of additional delayed imaging as part of a routinely deployed protocol for CTA evaluation of head and neck arterial patency would need re-evaluation.
References


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