Improvement of 3D Volume Selective Turbo Spin Echo Imaging For Carotid Artery Wall Imaging With Navigator Detection of Swallowing.


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**Aim**

To improve 3D volume selective TSE carotid artery wall imaging by the addition of navigators to reduce artefacts caused by swallowing.

**Introduction**

A number of magnetic resonance (MR) methods have been described for vessel wall imaging in research and clinical use.[1-3] The multiple contrasts required for characterisation, and the necessity for high resolution imaging often lead to increased imaging times. A method to improve image quality and avoid the need for repeat scans is therefore important. We have recently developed a 3D volume-selective TSE sequence for arterial wall imaging.[4] The primary advantage of this sequence is that it enables greater coverage of the volume of interest in the same amount of time as the equivalent 2D method, while maintaining the same signal-to-noise ratio (SNR), because of a significantly smaller phase-encode field of view (FOV). In 3D volume selective TSE scans of carotid arteries, blurred images have been observed when scanning some patients and this has been attributed to swallowing/throat motion during the scan. Artefacts may be caused by motion of the vessel and/or surrounding tissue or by the change in blood flow patterns caused by the increased heart rate on swallowing. Similar effects have been observed in other carotid imaging MR techniques.[5] Detection and removal of this motion is needed to improve image quality using the navigator sequence. Images are acquired during free breathing over several minutes, meaning that swallowing is likely to occur during the acquisition. The purpose of this study was to observe the effect and possible correction of artefacts due to swallowing motion during carotid artery wall imaging.

**Methods**

Images were acquired on a Siemens Magnetom Sonata 1.5T scanner. A 3D volume-selective Turbo Spin Echo sequence was used to image the carotid arterial wall in 6 healthy volunteers. A navigator accept/reject algorithm was added to assess the effect of swallowing motion.

Typical imaging parameters are FOV 120 x 24 mm, matrix size 256x52 (true resolution 0.47 x 0.47 mm), 18 slices each 2 mm thick, central slice located at the bifurcation, echo train length 11 and a short acquisition window of 65 ms to avoid motion blurring of the vessel wall due to pulsatility. For these T1 weighted images, TE was 11 ms and the acquisition was cardiac gated with dark blood double inversion preparation. The images and navigator were acquired using a 2-element phased-array coil (Machnet BV, The Netherlands). A cross-pair navigator placed on the back of the tongue was used to detect swallowing. This consists of slice selective 90° and 180° excitations, the intersection of which is positioned over and perpendicular to the back of the tongue forming a column of signal for one-dimensional frequency encode. This column runs in a head-foot direction and detects an edge on the tongue that moves with swallowing. The navigator was acquired in all scans, and in half was used with an accept/reject algorithm, with the remainder for monitoring of the swallowing pattern only. Prospective navigator gating with a ±2mm acceptance window was used. (Figure 1)

![Figure 1. Images showing position of crossed pair navigator and trace from 25 cardiac cycles of a scan with repeated swallowing.](image1)

Two swallowing patterns were tested, for one navigator and one non-navigator acquisition. For the first, subjects were asked to swallow half way through the scan, expected to represent a worst case single swallow. For the others, subjects were asked to swallow as often as possible. In the latter case this was around every 10-20 seconds during a 2 minute scan.

Signal intensity within the lumen (i.e. quality of blood suppression) was quantified and the images were ranked by 4 blinded observers in terms of the clarity of the vessel wall. The average score for the common carotid and start of the bifurcation were graded on a scale of 0-5 (where 0 = no vessel visible and 5 = good) taking into account visibility of the vessel, ghosting, clear delineation of inner and outer extent of the wall and lumen suppression.

**Results**

The blurring and ghosting in the $k_y$ (slice) and $k_z$ (phase-encode) directions causes a reduction in image quality throughout the 3D slab. A comparison of three slices from a typical scan is shown in Figure 2.

![Figure 2. Comparison of image quality in the common carotid.](image2)

**Discussion**

Heart rate was seen to increase on swallowing and often lasted for one or two cardiac cycles after the navigator returned to the normal accept position. The effect of the increased heart rate after a swallow is likely to have an effect on double inversion, blood suppression efficiency and therefore the increased amount of heart rate changes with repeated swallowing will have more effect on image quality.

A further improvement to this technique would be additional arrhythmia rejection that will also reject the additional short cycles that follow the swallow and/or incorporation of a more intelligent algorithm that will calculate the required double inversion time, which will be automatically adjusted during the scan. Even with the subjects swallowing as often as possible, the acceptance rate of the navigator sequence was >70%, therefore it is possible that this technique could be applied as a standard ‘safety net’ feature to help in the case of swallowing without affecting the image acquisition, or increasing the scan time, significantly.

**Conclusions**

Clarity of vessel wall delineation and the apparent efficiency of blood suppression are reduced by swallowing during acquisition. The image quality can be improved using a navigator accept/reject method. The difference seen is likely either to be an effect of a decrease in double inversion/blood suppression efficiency due to heart rate changes at the point of swallowing, or due to increased motional blurring/ghosting of tissue into the lumen. This method would help significantly in scans of the order of a few minutes long where a single movement during the scan can affect image quality.

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**References**


