"Shoot and Scoot" lower extremities MR angiography: First clinical trial

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Synopsis:

We studied the ability of the technique called "Shoot and Scoot" (S&S) [1], based on a segmented volume acquisition, to reduce the occurrence of venous return and to improve the spatial resolution of all the stations of the MR Angiography of the lower extremities. We compared two different types of k-space view ordering for the aorto-iliac and femoral stations: elliptic centric and centric. An analysis was done on all stations by consensus of two radiologists." Shoot and Scoot" appeared as an excellent technique to acquire the data of the third station sooner, therefore minimizing the percentage of impairing venous return, while improving the spatial resolution of the most proximal and distal stations.

Introduction:

Venous return in the tibio-peroneal area and low resolution of the most proximal and distal stations are two major drawbacks of MRA of the lower limbs. To reduce the venous contamination, contrast media is usually injected as a slow infusion [2]. This leads to a poor arterial CNR of the abdominal aorta due to the low arterial concentration of contrast media. Spatial resolution is also compromised to reduce the total acquisition time. We studied the potential of the "Shoot and Scoot" technique to improve the image quality of the MR angiography of the lower extremities.

Materials and Methods:

All images were obtained with a 1.5T Signa EchoSpeed (GE Medical Systems, Waukesha, Wi, USA) with 33 mT/m gradients. 33 patients (9 female-24 male; average age 67 years, min 48 – max 89 years) presented a symptomatic occlusive arteriopathy of the lower limbs. The S&S MRA was performed with the Peripheral phased array coil (USA Instruments) and optimized automatic table motion (5 sec between each station) on three stations: aorto-iliac, femoral and trifurcation area. A fast 3D RF phase spoiled gradient recalled pulse sequence was used in all stations. An elliptic centric view ordering was applied to the aorto-iliac and femoral stations for 23 patients. A centric encoding was applied to the same stations for 10 patients. An elliptic centric view ordering was used in the tibio-peroneal station for all patients. A total of 0.2 mmol/kg of paramagnetic contrast (Dotarem^{R}; Guerbet) was administered using an automatic power injector (Spectris, Medrad) and a biphasic injection: 40% of the dose at 1.4 ml/s immediately followed by the remaining 60% at 0.6 ml/s flushed with 40 ml of saline. The dose and the rate of the first phase of the injection protocol were higher than in the conventional protocol (30% of the dose at 1.2 ml/s) without S&S. Real-time visual bolus detection was used to trigger the beginning of the acquisition.

The technique used for the MRA was based on a segmented k-space acquisition called "Shoot and Scoot". During the first pass, only 50% of the data corresponding to the center of the k-space was acquired in the aorto-iliac and femoral stations while k-space was filled in total in the tibio-peroneal area. During the second pass the pulse sequence completed the collection of the outer data of k-space of the first and second stations. Merging temporal phases completed the k-space reconstruction. For each station, different obliquities, matrix sizes, number of partitions, and coil selection were possible [3]. The time to reach the distal station was 32 sec ± 3 sec, which was significantly shorter than the time of the conventional acquisition protocol, which is normally 58 sec for the same spatial resolution.

Typical acquisition parameters were: for station 1 & station 2, TR/TE: 3.4/1.3 msec, FA: 30°, Bw: 83.3 KHz, sl. Thickness: 3.2 mm ± 0.2 mm (interpolated by a factor of 4), 320x224 matrix, 0.5 NEX, FOV:46 cm; Station 3, TR/TE: 5.5/2.1 msec, FA: 40°, Bw: 62.5 KHz, sl. Thickness: 2.2 mm (interpolated by a factor of 2), 512x512 matrix, 0.75 NEX, FOV:46 cm.. A subtraction from a pre-injection mask scan was performed on all stations.

Image evaluation and results:

Two radiologists did a consensual reading station by station. Venous return was evaluated for each station according to a two-valued scale. For the station 1 & 2: positive or negative (presence of absence of venous return). For the trifurcation vessels, venous return was evaluated side-by-side as: non-impairing (superficial) or impairing (deep). In the aorto-iliac and femoral area, image quality was analyzed according to two criteria: the contrast level (in the aorta, common iliac, renal and superficial femoral arteries) and the amount of blurring of the vessels visualized. A measurement of the SNR was realized inside the aorta as well. In the tibio-peroneal area, the quality criterion was the level of contrast in the trifurcation vessels. All these criteria were analyzed using a four-valued scale: excellent, good, acceptable or poor. Finally, each station was globally evaluated according to the following scale: excellent, good, poor or non-diagnostic.

The image quality was estimated excellent or good in 82% of the patients for the aorto-iliac station, in 67% for the femoral station. All examinations were excellent, good or acceptable (100%) in the tibio-peroneal station. Venous return occurred in stations 2 in 15 % of the population. In station 3, 22% of the cases had no venous contamination, 64% (right) and 62% (left) had superficial venous contamination that did not impair the diagnosis in the trifurcation area, and 14% (right) and 16% (left) had deep venous contamination. With an Elliptic centric view ordering, 83% and 82% respectively of the first and second station were considered excellent or good while 80% and 30% were noted as good only (no excellent cases) with a centric encoding. The value of the SNR in the Aorta was 13.4 with elliptic centric versus 9.4 with centric. Blurring was noticed in 24% of the cases in the aorto-iliac area and in 69% in the femoral area.

Discussion and Conclusion:

Despite the high percentage of venous return occurrence, explained by the large number (61%) of diabetic patients in the population explored, the quality of most distal stations was much improved by the "Shoot and Scoot" technique. The reduction of the time to reach the tibio-peroneal area leads to an increase of the SNR in the trifurcation vessels, which allowed us to obtain a higher spatial resolution. The spatial resolution in the aorto-iliac and femoral stations was increased as well but some blurring artifacts and a noticeable reduction of signal in some areas damaged the image quality especially when centric encoding was used. This could be explained by the fact that during the first pass, not enough data from the center of the k-space were acquired with centric view ordering compared to elliptic centric. The discontinuity in amplitude and phase between the central k-space and the higher spatial frequencies is another fact that must be taken into account to further improve this technique. In conclusion, the S&S technique for lower extremities MR angiography demonstrated excellent performance in acquiring the data of the third station sooner, therefore minimizing the number of cases with impairing venous return, while improving the spatial resolution of the most proximal and distal stations.

Frontal MIPs of SNS

References:

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