Decreased venous contamination on 3D bolus chase peripheral MRA with thigh compression

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***Synopsis*:** Bilateral calf arterial flow and tissue enhancement measurements with a blood pressure cuff on one leg were performed with time-resolved MRA to determine the effect of thigh compression. Compared to the leg without compression, 60 mmHg inflation pressure delayed contrast arrival time to the trifurcation by only 4.7 ± 2.2 seconds but there was sustained suppression of tissue enhancement (> 40 seconds). This improved 3D bolus chase peripheral MRA allowing longer imaging times for higher resolution while eliminating venous contamination in the calves.

Introduction: Bolus chase peripheral MRA allows imaging from the abdominal aorta down to the ankles with a single injection of gadolinium. However one important limitation has been the difficulty in scanning fast enough with MR to keep up with the rapid flow of contrast down the legs. Patients with fast and intermediate flow (contrast travel time to popliteal artery trifurcation less than 25 seconds) tend to have venous enhancement in the third station of bolus chase peripheral MRA, which obscures arteries and limits diagnostic utility. The purpose of this study is to determine how much thigh compression applied with a sub-systolic (60 mmHg) pressure can slow down arterial flow and reduce venous contamination on the third station of 3D bolus chase peripheral MRA.

***Subjects and Methods*:** In 19 consecutive patients with contrast travel time to popliteal artery trifurcation less than 25 seconds, bolus chase peripheral MRA was performed with thigh compression by blood pressure cuff inflated to 60 mmHg and compared to 36 consecutive patients with similar flow rate but no thigh compression. The effect of thigh compression on arterial flow and tissue enhancement was assessed by applying compression to one leg during the time-resolved 2D projection MRA with 6 ml Gd. On 3D bolus chase MRA thigh compression was applied bilaterally. Venous contamination on the 3D images of the calf was graded as 0 = none; 1 = trace; 2 = mild; 3 = moderate and 4 = severe, non-diagnostic. Signal-to-noise ratio was measured in the popliteal artery.

***Results*:** Thigh compression slowed the arterial flow by 4.7 ± 2 seconds ($p < 0.001$). Thigh compression suppressed venous enhancement on the calf station from 1.9 down to 0.4 ($p < 0.05$) for intermediate flow (contrast travel time 20-25 seconds) and from 2.3 down to 0.9 ($p < 0.05$) for patients with fast flow (< 20 seconds). Thigh compression increased the popliteal artery SNR (81 vs. 52, $p < 0.001$).

Table 1. Effect of thigh compression on contrast travel time to trifurcation and soft tissue.

Contrast travel time (seconds)	Blood pressure cuff			
	with	w/o	Δ	p value
To trifurcation	19 ± 4	24 ± 4	5 ± 2	< 0.001
To soft tissue	35 ± 7	29 ± 9	6 ± 2	0.007

Table 2: Reduction in venous enhancement with thigh compression.

Flow rate	Compression	Venous contamination score					
		0	1	2	3	4	mean
Fast (< 20 s)	No (n* = 35)	1 3%	4 11%	18 51%	6 17%	6 17%	2.3
	BP cuff (n = 16)	3 19%	9 56%	4 25%	0	0	0.9**
Inter-mediate [20, 25]	No (n = 38)	4 11%	7 18%	17 45%	8 21%	2 5%	1.9
	BP cuff (n = 22)	13 59%	9 41%	0	0	0	0.4**

* n is based on number of calves; **$p < 0.01$

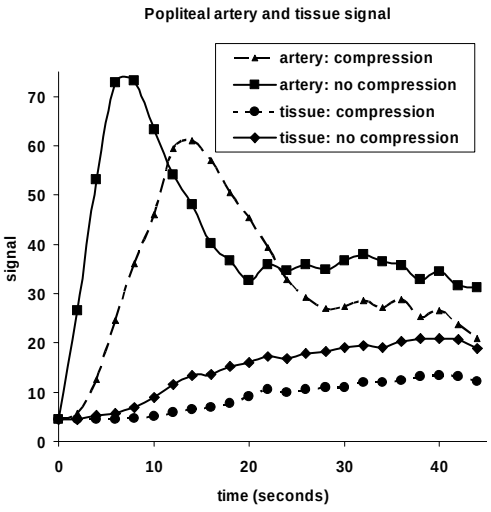

Figure 2. Arterial and soft tissue enhancement curves averaged for all patients with compression by blood pressure cuff showing right leg with compression (dark lines) and left leg without compression (dotted lines). To correct for temporal differences, the time axis was shifted to define 2 seconds before contrast arrival at the left trifurcation to be t = 0. Note that the blood pressure cuff compression delays and broadens the arterial peak and suppresses background tissue enhancement for > 40 seconds.

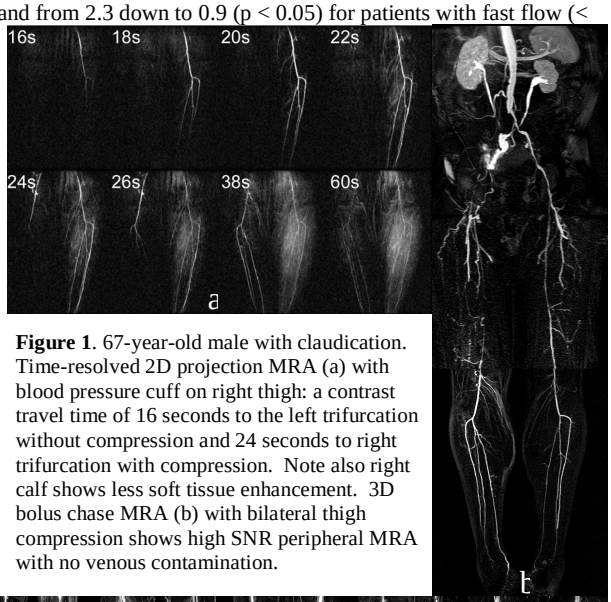

Figure 1. 67-year-old male with claudication. Time-resolved 2D projection MRA (a) with blood pressure cuff on right thigh: a contrast travel time of 16 seconds to the left trifurcation without compression and 24 seconds to right trifurcation with compression. Note also right calf shows less soft tissue enhancement. 3D bolus chase MRA (b) with bilateral thigh compression shows high SNR peripheral MRA with no venous contamination.

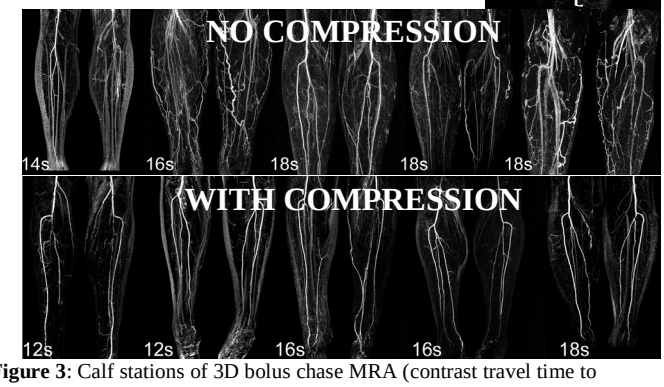

Figure 3: Calf stations of 3D bolus chase MRA (contrast travel time to trifurcation shown on each image): top) patients without thigh compression have venous contamination; bottom) with thigh compression to 60 mmHg: elimination of venous contamination.

Discussion: These data from 19 patients confirm the observations of Herborn et al, Bilecen et al and Meaney who all showed improved bolus chase MRA with sub-systolic thigh compression. Data from unilateral thigh compression during time-resolved MRA shows that the main benefit is not slowing down the arterial flow but rather a sustained suppression of venous and background tissue enhancement. The observation of increased popliteal artery SNR with thigh compression suggests that there is better matching of the peak of the bolus to the acquisition of central k-space data with increased sharing of the contrast bolus between stations. Slowing down the arterial flow and preventing venous contamination in the calf opens up opportunities for further improvements, which have not yet been fully explored. In particular, the elliptical centric ordering of k-space acquisition for the 3rd station allows for longer data acquisition with higher resolution. Perhaps 1024 x 1024 matrix acquisition will be possible once the scanner software is modified to allow such high resolution.