A Curved Thigh Cuff for Suppressing Venous Enhancement on Peripheral MRA

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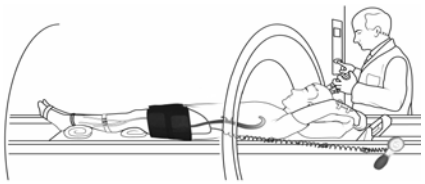
Introduction

Multi-station bolus chase MRA has revolutionized imaging of the peripheral vasculature. However, in many patients, the MR contrast agent bolus travels down the legs so quickly that the MR scanner cannot optimally image and move the table fast enough to keep up with the bolus. In this instance, sometimes referred to as fast flow, the bolus is not optimally "shared" among the stations and venous contamination may occur. Venous contamination is particularly frequent in patients with diabetes, cellulitis or foot ulcers due to rapid arteriovenous shunting. Besides, calf arteries are small and require higher resolution peripheral MR angiograms. Therefore, a longer arterial phase is crucial. This can be achieved by applying subsystolic compression to the thighs.



Thigh compression slows down blood flow and delays venous enhancement. This allows a longer acquisition time for arterial-only high resolution images without venous contamination. The precise compression pressure (typically 40-60 mm Hg), which is high enough to compress the veins but not the arteries, can only be achieved by using blood pressure cuffs.

Cuff Design

Standard blood pressure cuff designs are not appropriate for uniform, sustained and precise thigh compression, because the standard blood pressure cuff with an inflation bladder applies pressure primarily on one portion of the thigh. Applying the entire inflation on a focal area displaces the leg if the inflation bladder is positioned under or between the legs. Standard latex inflation bladders tend to leak, therefore re-inflation is necessary to maintain the desired pressure. When inflated, standard cuffs tend to slide down the thighs toward the knees, owing to the conical shape of the thighs, and become loose.

We have developed a curved blood pressure cuff for thigh compression to overcome these limitations of the existing cuffs. It has a Urethane laminate with a Velcro surface. The curved shape is optimized for a snug fit on the conical shape of the leg. Spot welds (59) prevent excessive bulging in any area and ensure uniform inflation throughout the entire cuff, thus minimizing the volume of air required for inflation. Less air in the cuff minimizes any shift in leg position from the cuff inflation. A double seal prevents air leaking. O-ring sealed connectors attach the cuff to an MRI compatible hand inflator or to an autoinflator operating with a pressurized oxygen source.

Autoinflator

The cuffs can be inflated with an oxygen or pressurized air source, which are commonly available in MR scanner rooms. For this inflation technique, a low pressure regulator with high precision and high flow is required. A two stage pressure regulator can be used if inflating with a portable oxygen tank.

Autoinflator (1 psi pressure reading corresponds to 50 mmHg on hand inflator).

Results

In 25 patients referred for a peripheral MRA, a 3D bolus chase was performed and venous arrival times were obtained for the calf on bolus chase MRA with multiple repetitions of the calf station. The mean time to venous enhancement with thigh cuffs inflated to 60 mm Hg was 134 $\pm$ 40 s (Table 1), ranging from 56 to 225 seconds (Figure 1). In 15 out of 49 legs (31%), veins did not show up even after repeating the calf station 3 times (~ 2 min). In 6 legs (12%), venous enhancement was identified on the first phase of the calf station, of which 3 had femoral-to-popliteal artery bypass grafts. However the enhancing veins tended to be superficial and did not substantially interfere with visualization of calf arteries.

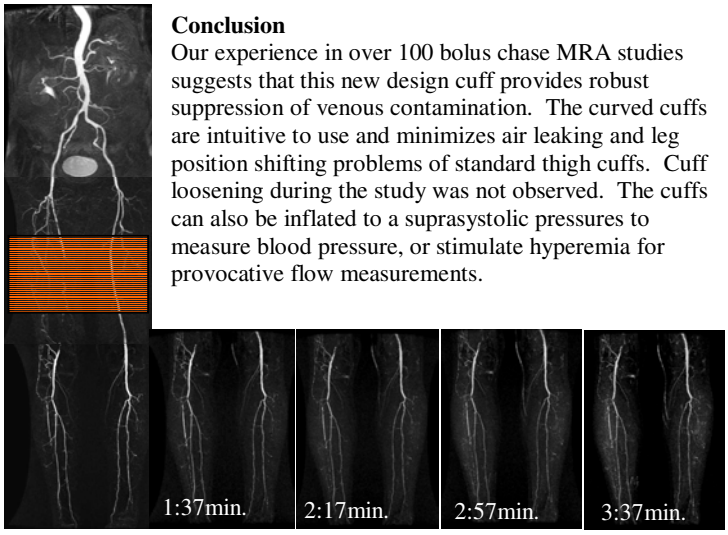


Figure 1. Calculation of time to venous enhancement in the calf.

Conclusion

Our experience in over 100 bolus chase MRA studies suggests that this new design cuff provides robust suppression of venous contamination. The curved cuffs are intuitive to use and minimizes air leaking and leg position shifting problems of standard thigh cuffs. Cuff loosening during the study was not observed. The cuffs can also be inflated to a suprasystolic pressures to measure blood pressure, or stimulate hyperemia for provocative flow measurements.

Table 1. Mean time to venous enhancement

	Leg #	Time to venous enhancement	Ratio	p-value
With cuff	49	134 $\pm$ 40 seconds	3.8	<0.01
W/o cuff	172	35 + 14 seconds		

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