Carotid Screening: How Much Information Does a Single M-line Carry about Arterial Stiffness? – The Maastricht Study

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Introduction

Background

- Arterial stiffness is a very powerful predictor of CVD at their early stages

- Monitoring arterial stiffness can help to reduce the global burden of CVD

- Tracking the phase of radiofrequency from multiple M-line ultrasound gives an accurate and precise estimate of common carotid artery (CCA) stiffness

- Costly, high operator dependent, high operator expertise requirements, arduous measurement procedure, and relatively time consuming

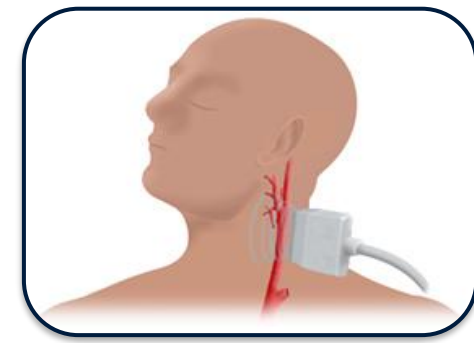- Does not meet the need for screening tools in resource-constrained areas

Purpose

- Assess whether a single M-line would be sufficient for screening purposes in low resource settings
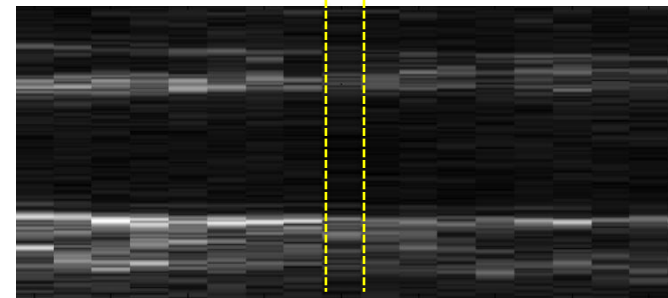
Material and Methods

[1]

- ➤ Longitudinal CCA from 500 subjects from The Maastricht Study (61 years, 52% male)

- ➤ Recordings are composed of 17 lines covering an area of 16.32 mm, high frame rate

- ➤ Multi M-line measures obtained by averaging over the 17 lines

- ➤ The middle line was used for the single M-line approach

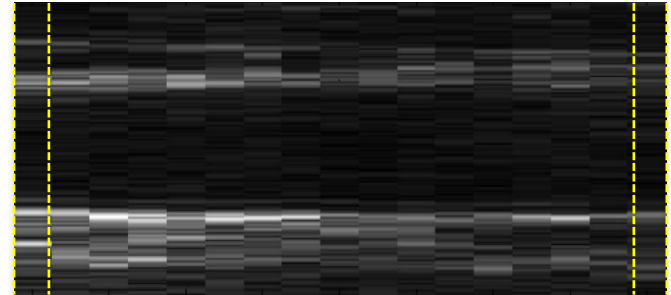$$DC = \frac{2\Delta D.D + \Delta D^2}{PP.D^2} \qquad YEM = \frac{1}{DC} * \frac{D}{IMT}$$

$\mu(1, ..., 17)$

[1] Sources: http://www.sbadandrmc.com/our-services-patient-education/ultrasounds-85ea/carotid-ultrasound/

Material and Methods

Statistical analyses

➤ Assess accuracy using Wilcoxon test and Bland-Altman analysis

➤ Assess reproducibility using coefficient of variation (CV) based on 3 repeated measurements

➤ Sensitivity analysis using middle, first and last M-lines

Results & Discussion

Accuracy

	Multi M-line	9th M-line	p-value
Diameter (μm)	7736 [1096]	7721 [1154]	0.16
IMT (μm)	817 [195]	830 [218]	0.14
Distension (μm)	368 [163]	370 [164]	<0.05
DC (1/MPa)	14.3 [6.6]	14.4 [6.6]	<0.05
YEM (MPa)	0.65 [0.33]	0.64 [0.34]	<0.05

Data is expressed as median [IQR]

➢ Differences in diameter and IMT are not statistically significant
➢ Differences in distension, DC and YEM are statistically significant however not technically or clinically relevant
  o Large statistical power due to large sample size

Results & Discussion

Accuracy

Bland Altman

	1st M-line	9th M-line	17th M-line
Diameter (µm)	106 (-314 to 527)	**4.2 (-182 to 190)**	-233 (-1099 to 625)
IMT (µm)	7 (-185 to 198)	**-5.3 (-128 to117)**	-7 (-283 to 268)
Distension (µm)	27 (-86 to 140)	**-4.1 (-42 to 34)**	0.7 (-161 to 163)
DC (1/MPa)	1 (-3.5 to 5.3)	**0.2 (-1.8 to 1.5)**	0.4 (-6 to7)
YEM (MPa)	-0.05 (-0.5 to 0.4)	**0.0005 (-0.22 to 0.21)**	-0.13 (-1.3 to 1.1)

Data is expressed as Bias (lower LOA to upper LOA)

➢Bland Altman reveals good agreement
➢Wider limits of agreement in case of M-lines on edges

Correlation analysis

	1st M-line	9th M-line	17th M-line
Diameter	0.96	**0.99**	0.90
IMT	0.83	**0.92**	0.74
Distension	0.88	**0.99**	0.83
DC	0.89	**0.99**	0.81
YEM	0.86	**0.98**	0.76

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Results & Discussion

Reproducibility

	Multi M-line	1st M-line	9th M-line	17th M-line
Diameter (%)	**2.2**	2.7	**2.5**	5.2
IMT (%)	**8**	14	**12**	18
Distension (%)	**11**	13	**12**	19
DC (%)	**12**	13	**13**	21
YEM (%)	**16**	22	**19**	30

➢ The middle line achieves the best reproducibility compared to those on edges
➢ Differences between reproducibility CVs obtained from single and multiple M-line are moderate in magnitude

Conclusion & Future work

Conclusion

➢ Single M-line ultrasound can assess arterial stiffness with very acceptable precision and accuracy

➢ **Future perspective**: Enabling Image free, single M-line tools to support screening in low resource settings globally

Future work

➢ Systematic enlargement of the spatial averaging window
➢ Repeat the analysis for all the other M-lines and visualize the behavior of differences
  o *Hypothesis*: plateau in the middle and very steep increase of difference on edges

Acknowledgements

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Thanks for the attention!