Webinar Q&A Report:
Pulse Wave Velocity: Theory, Applications, Methods, and Future Directions

How can an increase in PWV be treated clinically?

Increased PWV comprises elements of both vascular structure and function. General lifestyle modifications would likely be the first course of action, including meeting physical activity guidelines (e.g. 150 min of moderate-intensity aerobic exercise per week), dietary modification if necessary (reduced saturated fat, refined sugar, etc.). Since blood pressure also affects PWV, a BP lowering med may also decrease PWV, such as beta-blocker, diuretic, etc.

When assessing ICC for repeated measurements, should blood pressure levels be considered for normalization of the data?

Yes, generally it is recommended that mean arterial pressure is used as a covariate.

If doing repeated measurements in pregnancy starting in trimester one, could you re-use the distance measure you have for following trimesters?

With the distance measurements, we want to try and get a linear distance that avoids contours, which would obviously change throughout the course of the pregnancy. I would suggest repeating the distance measurement each trimester, but ensuring that each time you make this measurement, it is using a consistent method that avoids the contours (e.g. of breasts, pregnant belly).

What is the degree of success in acquiring PWV in babies and would brachial ankle be the best option from a feasibility point of view?

Little work has been done with PWV in babies, however we have shown that it is possible with brachial femoral measurements in which finger cuffs were adapted for the limbs of the babies. Brachial ankle may be another possible option, but since the descending aorta is the most important segment, the brachial femoral may best capture this segment compared to the ankle measure which would take into account more of the lower limb vasculature.

What is the best way to prevent arterial stiffness; for example, aerobic exercise, etc.?

I think we need to be careful with the word prevent. Stiffening of the arteries is an inevitable aspect of aging. We can slow the trajectory through positive lifestyle factors including meeting physical activity guidelines (achieving 150 min of moderate-intensity aerobic exercise/week), dietary modifications (reducing saturated fat, minimizing refined sugars, etc), stress-management, and minimizing long bouts of sedentary behavior.

Which position could be the ideal to measure pulse wave velocity in pregnant women?

This may depend on how pregnant the woman is. If the woman is in their first trimester and is not “showing” substantially, the supine posture, similar to normal populations, would be ideal. However, if the woman is “showing” (eg. big belly in third trimester), it may be necessary from a safety/comfort standpoint to have the woman lay slightly on her side, with the cuffed side not being the side that was being laid on. In this case, distance should still ideally be measured in a completely supine position.

Why does the PWV increase when vessel stiffness increases?

As the stiffness of the vessel increases, the pressure waves bounce more quickly off of the vessel walls and thus the velocity at which it travels is quicker (think about throwing a tennis ball at a concrete wall versus a padded wall; the tennis ball will bounce back quicker off of the concrete wall compared to the padded wall).

As MRI determined PWV is performed lying flat is there a systematic difference between those values obtained by MRI and the gold standard?

Regardless of MRI or tonometry/oscillometry, it is recommended that participants are measured in a supine position, so there would not be a difference associated with body position. Indeed, many oscillometry/tonometry devices are validated against MR measurements. There may be more of a difference associated with the more local/regional view of aorta that MR gives us compared to more segmental/global view that tonometry/oscillometry gives us. Some articles that provide further insight into these considerations are: https://pubmed.ncbi.nlm.nih.gov/21805314/, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3996237/#r65, and https://pubmed.ncbi.nlm.nih.gov/11583892/

Does vitamin D status affect PWV, particularly in differences between populations of different ethnicities? And does season measured affect PWV i.e. lower in summer and higher in winter?

I am not familiar with any literature demonstrating differences with Vitamin D, though Vitamin D is associated with sunlight/time outside and thus indirectly be associated with physical activity levels which may impact stress and general wellness, all of which could very well impact PWV. There may also be genetic and socio-cultural differences in PWV with ethnicity related to intrinsic vascular properties and presence/lack of racism/discrimination respectively. A brief literature search did show a potential link between vitamin D and PWV, though evidence seems to be inconsistent and the relationship may exist only in those that were previously Vitamin D deficient. For more information here, see: https://pubmed.ncbi.nlm.nih.gov/31809869/, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5721873/, and https://pubmed.ncbi.nlm.nih.gov/26824510/

Do you have any experience applying PWV analysis in rodent models and do you recommend a particular technique for this purpose?

We are not well versed in animal PWV, however I know that it is not uncommon. A brief search indicates it has been measured using ECG, ultrasound, as well as more invasive catheterization with pressure transducers: https://pubmed.ncbi.nlm.nih.gov/23185005/, and https://pubmed.ncbi.nlm.nih.gov/?term=rat+pulse+wave+velocity&sort=date&sort_order=asc&filter=pubt.meta-analysis&filter=pubt.review. You may also be able to reach out to the UNC Dept of Pathology/McAllister Heart Institute which conducts basic vascular research and may be more familiar with this literature: https://www.med.unc.edu/pathology/, and https://www.med.unc.edu/mhi/

Can you use the PowerLab to measure PWV?

Powerlab can be used as an acquisition device for physiological measurements (ECG, PPG, TCD, etc) that can be used for the PWV calculation. More specifically, the powerlab can acquire inputs from these signals, display the data in a chart format, and the labchart software that is associated with the powerlab can be used to formulate macros (coding) to measure the time component of the PWV calculation (e.g. time from a peak of one signal to a peak of another signal). We should be publishing a paper on this in the coming months which will outline this more clearly, so stay tuned! Here is also some information that may be useful from the ADI website: https://www.adinstruments.com/research/animal/tissue-and-circulation/pulse-and-plethysmography

What effect does acute and chronic exercise have on PWV?

This may depend on how soon after exercise the test occurs. Recall that BP impacts PWV. So, if BP is acutely raised after moderate to vigorous exercise, PWV will likely be elevated as a function of increases sympathetic activity. However, if the test is done, say 15-30 minutes following exercise, during a time in which there may be a vagal/parasympathetic rebound in which BP lowers, then PWV will also be lower. Chronic exercise, particularly moderate aerobic exercise has a lowering effect on PWV.

Is there an accreditation to become certified in taking PWV measures comparable to the ISAK?

Not that I am aware of, however there are methodological recommendations provided by the Artery Society: http://www.arterysociety.org/, https://www.sciencedirect.com/science/article/abs/pii/S1872931210000165. We also recommend performing pilot testing ensuring between good tester reliability (if multiple testers are necessary), as well as good between-day and within-day reliability prior to collecting data that will be formally analyzed.

Can PWV predict cognitive decline?

This is an area of interest that has yet to be fully explored. It does appear that PWV and cerebral arterial stiffening are linked to cognitive outcomes and potentially may be useful in the context of predicting outcomes related to cognitive decline.

What device works best to measure PWV in young infants?

We previously used the Vicorder oscillometric device successfully, however this has not been widely applied to infants previously. Applanation would be difficult with an infant. See our group's recent paper: https://pubmed.ncbi.nlm.nih.gov/32565542/

Would the presenters consider mentoring a team of pediatric cardiologist at Children's Mercy Hospital? If yes, how do we contact them?

I think this would be feasible. Please contact Lee (mailto:,dr.l.stoner@gmail.com) and Gabe (gzieff@live.unc.edu)

Regarding PWV and prolonged sitting studies, do you take the distance measurements sitting rather than supine? Could you also comment on other obstacles with PWV in sitting studies?

No, we would take the measurements supine to get as linear a distance as possible so as to avoid body contours. You may however, want to take PWV measurements both supine (as this is standard practice) and seated (as this may be of more interest to your research question). Then you can report both. Briefly, other considerations with sitting studies include:

1. timing (e.g. carefully consider when PWV measures will occur in a sitting position following the transition from supine…you don't want too soon of a measurement which would be affected by the orthostatic challenge of the postural change)
2. controlling for leg fidgeting
3. trying to keep a subject awake/alert without over-stimulating them (e.g. wouldn't want to have them watch an exciting action-packed movie, but also don't want them to doze off)

I was interested in the cerebral pulse wave velocity measurements you mentioned. Is this done just using ECG and transcranial doppler? Are there other methods that are used?

Yes, this is correct. This has not been widely done outside of our lab. Our approach has used ECG and TCD, using ADI labchart system for real-time data acquisition. Another complimentary device that could be used alongside this to obtain related/potentially explanatory variables would be functional NIRS system to look at changes in oxygenated and deoxygenated hemoglobin and neurovascular coupling.

Is there any correlation between endothelial function and PWV ?

Yes, acute changes in endothelial function have been shown to be associated with PWV. For example, please see our paper on this topic: https://pubmed.ncbi.nlm.nih.gov/32490736/. However, keep in mind that PWV is also a measure of vascular structure, not only function.

Do you have any recommendations for assessing PWV during an acute perturbation (e.g., handgrip, CPT, etc.)?

Yes, PWV can be used in the context of acute perturbations but extra care must be taken in terms of making sure to consider important factors such as timing of measurement in relation to the perturbation, having an appropriate control or baseline condition, accounting for posture-associated changes in blood pressure, etc.

If you have additional questions for ADInstruments regarding content from their webinar or wish to receive additional information about their products and laboratory services, please contact them by phone or email:

ADInstruments, Inc.

77 Vogel Street, PO Box 587
Dunedin, New Zealand, 9016

https://www.adinstruments.com

Email: sales@adinstruments.com