Arterial Pulse Wave Velocity and Heart Rate

To the Editor:
The concerns raised by Lantelme et al1 about the relationship between heart rate and pulse wave velocity (PWV) properly apply to the method they employed, not to the conventional method, nor to the long-established relationship between PWV and arterial stiffness. Lantelme et al used Complior, as did the 3 other studies (Lantelme references 8, 15, 17), which appeared to show increasing PWV with increasing heart rate. In Complior, the sensor used to detect the pulse produces a signal, which is related to the derivative of the pressure pulse. A proprietary algorithm is then used to identify the waveform in a proximal and in a peripheral artery, to measure the time difference between the 2 sites, and thereby to calculate pulse wave velocity from the distance between the sites. In the conventional method, PWV is measured from the time delay between the foot (sharp initial systolic upstroke) of the wave at the 2 sites.

The theoretical and experimental basis for using PWV as a measure of arterial stiffness was established in the nineteenth century, and the earliest clinical studies were conducted in 1922.2 We are unaware of data similar to those presented by Lantelme, showing any significant relationship between heart rate and PWV using the conventional method, nor can we conceive any theoretic basis for such.3,4 Because increasing heart rate is associated with an increase in the rate of systolic rise and abbreviated diastolic duration, the most likely explanation for Lantelme and coworkers’ finding is that the algorithm used to obtain transit time from the whole waveform is affected by these changes in waveform shape. The foot of the waveform is determined by the high frequency components in the pulse wave (greater than 10 Hz), and their contribution to the wave foot does not change with heart rate.3 The foot-to-foot velocity is related to the phase velocity of the high frequency components, and because the dynamic elastic properties of the arterial wall do not alter appreciably at high frequencies, it is inconceivable that there should be a passive effect on arterial stiffness simply by altering the input frequency. The alternate explanation the authors offer in terms of tachycardia resulting in vessel stiffening as a passive effect by shortening the time available for recoil then becomes difficult to understand.

Complior is a convenient method for measuring PWV. Its initial evaluation5 did not include studies as comprehensive as those described by Lantelme et al. Unless these concerns can be addressed, the conventional method for measuring PWV from the wave foot is preferred when any change in heart rate is possible.

The authors of this paper described carotid-femoral pulse wave velocity as a marker of atherosclerosis. This is simplistic and incorrect.1 Our earliest studies showed no difference in PWV between comparable groups of subjects in populations with high and low prevalence of atherosclerosis, but similar changes in each with aging.6 Megnien et al7 from Paris showed that aortic stiffening does not predict atherosclerotic disease in asymptomatic men at risk. Elevated arterial PWV is a measure of sclerosis, and this results most commonly from aging and hypertensive medial degeneration, not from intimal atherosclerosis.3

Response: Heart Rate and Pulse Wave Velocity

In our recent report,1 we used an automatic device for pulse wave velocity (PWV) measurement that is commercially available (Complior, Colson). This decision was based on the fact that, for a clinical application, an automatic method rather than a manual one (which remains the gold standard) would be preferentially chosen. Indeed, the conventional (ie, the manual) method is tedious and time consuming, which probably precludes its application on a routine basis. The Complior device has been validated in comparison with the manual method in more than 50 men and women of various age, blood pressure, and heart rate levels.2 We are unaware of any report of an effect of heart rate on the algorithm used to calculate the delay between the 2 pulse waves. In the validation study,2 the range of heart rate levels within the group was probably wide. If our finding of an effect of heart rate on PWV measurement were due to the Complior device, it would have been difficult to observe such a high agreement between the 2 methods (r=0.99, P<0.001). Moreover, the relationship between PWV and heart rate found in our study1 was continuous among the pacing frequencies tested, each additional 10 bpm leading to a PWV increase. It is very unlikely that such a minor heart rate variation would influence the algorithm of the Complior device.

A relationship between heart rate and PWV assessed by the conventional method has indeed been reported in an epidemiological study.8 Other major determinants were age and blood pressure. Using the Complior device, the very same determinants (including heart rate) were able to significantly influence PWV, further emphasizing the similarity of PWV determined by the 2 methods.4 When considering the effect of heart rate on PWV

Christopher S. Hayward
St Vincent’s Hospital
Sydney, Australia
E-mail cshayward@stvincent.com.au

Alberto P. Avolio
Graduate School of Biomedical Engineering
University of New South Wales
Sydney, Australia

Michael F. O’Rourke
St Vincent’s Hospital
Sydney, Australia


Michael O’Rourke is a Director of Atcor Medical Pty. Limited, Sydney, Australia, maker of instruments for analyzing the arterial pulse.
within individuals, we found at least one report using the conventional method showing a relationship between heart rate and PWV during exercise. More recently, using the Complior in paced patients, Albaladejo et al also showed a trend for PWV to increase with heart rate.

Also, the effect of heart rate on PWV is in accordance with animal studies. Using atrial pacing, it has been shown that heart rate changes were able to influence arterial distensibility. Because the viscous component of the elastic wall is highly frequency dependent, it can be expected that higher heart rate values are associated with reduced distensibility. The shortening of the time available for recoil may be a plausible, although not an exclusive, explanation.

It is very likely that automatic methods of PWV measurement will be preferred for large studies or routine clinical application. In addition, the Complior has been shown to provide with an estimate of PWV that is of high clinical value because it is a strong marker of cardiovascular risk in hypertension, in line with previous reports obtained with the conventional method. We believe that it is critical to determine the potential confounders of the automatic methods of PWV determination.

Pierre Lantelme
Christine Mestre
Service de Cardiologie
Hôpital de la Croix-Rousse
Hospices Civils de Lyon
Faculté de Médecine Lyon-Nord
E-mail pierrelantelme@hotmail.com

Michel Lievre
Service de Pharmacologie clinique
Lyon, France

Alain Gressard
Hugues Milon
Service de Cardiologie
Hôpital de la Croix-Rousse

Arterial Pulse Wave Velocity and Heart Rate
Christopher S. Hayward, Alberto P. Avolio and Michael F. O'Rourke

Hypertension. 2002;40:e8-e9; originally published online October 21, 2002;
doi: 10.1161/01.HYP.0000038734.25997.A9

Hypertension is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2002 American Heart Association, Inc. All rights reserved.
Print ISSN: 0194-911X. Online ISSN: 1524-4563

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://hyper.ahajournals.org/content/40/6/e8

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published
in Hypertension can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial
Office. Once the online version of the published article for which permission is being requested is located,
click Request Permissions in the middle column of the Web page under Services. Further information about
this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Hypertension is online at:
http://hyper.ahajournals.org//subscriptions/