Letters to the Editor

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Arterial Wave Reflections

To the editor:
The article by London et al1 shows the danger of ignoring assumptions implied in the derivation of a relation. The two graphs in Fig 2, here called Figs 2a and 2b, show two carotid ("central") pressure signals, both exhibiting secondary peaks attributed to "pressure augmentation" by reflection. The figure defines the quantities referred to below. Whereas Fig 2a exemplifies the usual form of this phenomenon,2,3 Fig 2b shows the reflection commencing well after the peak of the forward pressure wave has passed.

For both signals, augmentation can only occur after P1, i.e., the arrival of the reflected wave. For Fig 2b, this means that the amplitude representing ΔPp is the amount by which the second peak exceeds the extension of the descending systolic pressure value, estimated as 6 mm Hg from Fig 2b. Then ΔP/Pp is also 25%. The implied assumption for the determination of ΔP is the arrival of the "reflection" near a flat systolic maximum, so that there is no significant change in pressure of the forward wave between P1 and Pp. Only then can ΔP measure the amplitude of the reflection.

There is a further discrepancy in ΔP/Pp for the two graphs. The former is referenced to the augmented value, whereas the latter refers to a Ppi value for the forward wave only. Comparing the augmentations with the amplitudes of the forward wave only, ΔP/Pp for Fig 2a (now 10/30=33%) significantly exceeds the corresponding value for Fig 2b.

H. Kobler
Cardiovascular Research Unit
Department of Cardiology
Royal North Shore Hospital
St Leonards, NSW, Australia

The following is in response:

To the editor:
The letter by H. Kobler is an illustration of the misunderstanding of some principles concerning the analysis of arterial wave reflections on pulse pressure contour.

Arterial wave reflection is a natural counterpulsation whose effect on pulse contour in central arteries depends on the timing of forward and reflected wave. An early return of reflected wave causes an increase in pulse pressure (and peak systolic pressure). This "boosting" effect of wave reflection influences the amplitude and shape of pulse contour. Muro and his associates1-2 classified the configuration or contour of pressure waves in central arteries into three classes, based on the timing and prominence of the secondary wave caused by reflection: (1) Type A (Fig 2a in London et al3) is characterized by a late systolic peak (Ppa) occurring in late systole after the inflection point (Ppi) marking the apparent onset of the retrograde wave. The amplitude of late systolic peak (Ppa-Ppi) to total pulse pressure amplitude (defined as the augmentation index) is in type A greater than 12% of pulse pressure. (2) Type B: Ppa occurs also in late systole following the inflection (Ppi). The augmentation index is between 0% and 12%. (3) Type C (Fig 2b in London et al3): The peak systolic pressure (Pps) is near the mid systole and precedes the inflection point (Ppi) and is followed by a secondary wave peaking in the early diastole. The reflected wave does not influence the pulse pressure amplitude or peak systolic pressure, and the augmentation index is therefore negative. Type C corresponds to a delayed return of wave reflection with a "boosting" effect on protodiastolic pressure and on the diastolic pressure-time index.4 This is a condition observed in young subjects with good ventricular-vascular matching. Each type of pulse is associated with a distinct impedance spectrum.5 Muro's classification is accepted by the majority of authors, including ourselves.

From Dr Kobler's letter it also appears that he confuses inflection point (Ppi) with the peak value of forward incident wave. This is not always the case; Ppi is not necessarily the peak value of the forward wave, and Ppa-Ppi is not the absolute amplitude of reflected wave. Therefore, Dr Kobler's expression of the "reflection coefficient" as (Ppa-Ppi)/Pps has no specific meaning. The same remark concerns his analysis of the type C wave on Fig 2b.3 Indeed, the extension of the descending systolic pressure value cannot represent the decay of the forward wave, because in the presence of wave reflections this part of the pressure wave could already be affected by reflected wave. The definition of the augmentation index as the ratio by which the second peak exceeds the extension of the descending systolic pressure is meaningless at least as the effect on pulse pressure and peak systolic pressure is zero. For the evaluation of the absolute values of forward and backward waves, a quite different approach of analysis (in the frequency domain) is necessary.6,7 and only in these conditions does the ratio between incident and retrograde pressure wave express the reflection factor, sometimes called reflection coefficient, which is quite different from the augmentation index used in our study. Augmentation index is the measure of an effect of wave reflection. It is not a measure of reflection.

Gérard London
Alain Guerin
Bruno Pannier
Sylvain Marchais
Athanase Benetos
Michel Safar
Centre Hospitalier Médical F.H. Mabés
Fleury Mérogis, France

References
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H Kobler

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