SUMMARY. The effects of the calcium-entry blocker nicardipine on brachial hemodynamics were studied in 22 patients (18 male, 4 female) with essential hypertension, who were treated with 20 mg tid for 1 year. Compliance, characteristic impedance, vascular resistances, and tangential tension were measured before treatment and after 1, 3, and 12 months of treatment by an automatic recording from a B-mode, high-resolution, real-time scanner and pulsed Doppler velocimetry for the calculation of the flow volume. We observed statistically significant variations in compliance and impedance after 1 month (3.21 ± 0.59 dyn cm⁻¹ 10⁻⁷ vs. 1.26 ± 0.16 dyn cm⁻¹ 10⁻⁷ and 50.6 ± 4.7 dyn cm⁻⁵ 10² vs. 91.4 ± 7.3 dyn cm⁻⁵ 10², respectively; mean ± SEM; p < 0.001), while tangential tension was significantly reduced after only 3 months (23.2 ± 2.2 mmHg vs. 25.4 ± 2.3 mmHg cm; p < 0.05). The correlation between variations in mean blood pressure and in the hemodynamic parameters studied remained statistically significant throughout the study. Nicardipine improved the parameters of large-artery hemodynamics that favor a normal systolic pulse.

KEY WORDS. hypertension, nicardipine, forearm arterial compliance, pulsed Doppler

The main hemodynamic feature of hypertension is increased peripheral resistance [1] with structural alterations of the precapillary arterioles that take place during the natural history of the disease [2, 3]. The large arteries play an important role in circulatory homeostasis, since part of the blood propelled by cardiac systole is held by the large arteries and has positive effects on the pulse pressure and myocardial metabolic demand [4]. Modifications to the large arteries are related, on one hand, to peripheral resistances and, on the other hand, to intrinsic arterial wall modifications, which are in turn dependent on the state of contraction of the medial smooth muscle, the amount of collagen and elastin, and, above all, on structural alterations and degeneration of the vessels.

Successful antihypertensive drug therapy should lead to a hemodynamic improvement of large arteries [5]. Non-invasive techniques now make it possible to perform well-tolerated and easily repeated measurements of vessel diameter, pulse wave velocity, and flow volume, as well as to calculate compliance, characteristic impedance, and local resistance. Though aortic hemodynamics can be measured by such methods, they are more simply and more conveniently applied to peripheral vessels such as those of the forearm.

Nicardipine is a dihydropyridine calcium-entry blocker that has been shown to improve hemodynamics in hypertension, both during acute treatment and after 3 months of therapy [6, 7]. Against this background, we set out to ascertain if these positive hemodynamic effects are maintained in chronic therapy and, above all, to evaluate any correlation in time between the nicardipine-induced increase in vessel diameter and wall tension.

Materials and Methods

We treated 22 essential hypertensive patients (WHO Class I–II) (18 males, 4 females; mean age, 46 years; age range, 33–64 years) with nicardipine, 20 mg tid, for 1 year. All subjects had either undergone pharmacologic washout for at least 1 month or had never been treated previously. No patients presented cardiac, renal, or neurologic complications. Patients were diagnosed as essential hypertensives by the usual clinical, laboratory, and instrumental evaluations.

Hemodynamic parameters were measured before treatment and after 1, 3, and 12 months, with the patient in a supine position after at least 15 minutes rest in a comfortable environment.

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Pulse wave velocity (PWV) was measured in the forearm by two morphooscillographic cuffs in series. Measurements were recorded on a Battaglia–Ran gonon Multistylus 4, with paper running at the maximum speed (10 cm/sec). PWV was then calculated as the ratio of the distance between the cuffs (center-to-center) and the interval between troughs on simultaneous recordings from the two (mean calculation from at least ten measurements). The value observed in a control group of normotensive subjects was 446±27 cm/sec; reproducibility was 7±2%. Brachial arterial diameter (D) was measured by a high-resolution B-mode duplex scanner (Diasonics CV 400) with a 10-MHz probe. The value observed in a control group of normotensive subjects was 44.3±1.8 cm 10⁻².

As described by Farrar et al. [8], compliance was then calculated by Bramwell and Hill’s equation:

\[ C_0 = \sqrt{\frac{dP}{\rho} \frac{V}{dV}} \text{ hr,} \]

where \( C_0 = \text{PWV}, P = \text{pressure}, V = \text{vessel volume per unit of length}, \pi = \text{plasma density}. \text{Arterial compliance was then calculated by the formula:} \]

\[ \frac{dV}{dP} = \frac{\pi D^2}{4 \rho C_0^2} \text{ hr,} \]

expressed in dyn⁻¹ cm⁴ 10⁻⁷. The characteristic impedance was calculated by McDonald’s formula [9]:

\[ Z_c = \frac{4 \rho C_0}{\pi D^2} \text{ hr,} \]

expressed in dyn s cm⁻⁵ 10⁻².

Blood flow in the brachial artery, calculated as the mean flow velocity per vessel section (\( Q = \pi D^2/4 \text{Vm} \)), was automatically indicated in ml/min by the scanner software. The mean velocity was calculated by frequency spectrum integration obtained by pulsed Doppler velocimetry.

Arterial resistance was calculated in mmHg s/ml as the ratio between the mean blood pressure and volume flow (\( R = \text{PAM}/Q \)). Tangential tension (T) was obtained by Laplace’s Law as:

\[ T = \frac{P R}{\text{mmHg cm}}, \]

where P is the mean blood pressure and R the vessel radius.

Variations of BP and HR in the first, third, and 12th month were compared with basal values and subjected to statistical analysis by Student’s t test for paired data. Normality of the distribution of values for diameter, compliance, characteristic impedance, local resistances, and tension was assessed at the various times of observation by Kolmogorov-Smirnov’s Goodness Fit test. Analysis of variance and Wilcoxon’s test were used to identify any statistically significant variations. The multiple regression test was used to ascertain any significant correlation of variations compared with basal values of the various parameters. Bonferroni’s correction was taken into account in the assessment of the statistical significance.

Results

The treatment was well tolerated, with no dropouts. The blood pressure was significantly reduced after 1 month of therapy, this improvement being maintained without appreciable variation at subsequent visits. The heart rate showed no significant alterations (Figure 1).

Table 1 shows the diameter, compliance, characteristic impedance, peripheral resistance, and tangential tension. Compliance is seen to have increased significantly, while the characteristic impedance and

![Graph showing variations of BP and heart rate during treatment with nisardipine (mean ± SEM).](image-url)