Shiraz Kareem
Dr. med.

**Measuring Ankle Brachial Pressure Index (ABI) In Peripheral Arterial Occlusive Disease: Do the Guidelines of the American Heart Association Need To Be Changed?**

Geboren am 23.02.1967 in Ernakulam, Kerala/Indien
Staatsexamen am 25.8.1990 an der Universität Mangalore

Promotionsfach: Innere Medizin
Doktorvater: Prof. Dr. med. Curt Diehm

Ankle brachial pressure index (ABI) is used to assess lower limb arterial perfusion. According to the currently existing guidelines by the American Heart Association; it has been agreed that the ABI of a lower limb i.e. either the left or the right, is defined as the quotient of the higher of the systolic blood pressures (SBP) of the two ankle arteries of that limb (either the anterior tibial artery or the posterior tibial artery) and the higher of the two brachial SBP of upper limbs. The investigators however hypothesised that considering the lower of the two ankles SBP of a side as the numerator and the denominator as the highest of the brachial SBP would increase the diagnostic yield from this investigation. This method of calculation of ABI is termed by the investigators as the *low ankle pressure* (LAP) method and the former, i.e. the currently practiced method is termed as the *high ankle pressure* (HAP) method.

This was a cohort study, comprising of 216 subjects. It was performed in order to answer the question whether the HAP or the LAP method of calculating ABI is better in the diagnosis of PAD. This study was hence designed to identify PAD, particularly the asymptomatic cases and it estimates the lower limb haemodynamic status, thereby assessing haemodynamic magnitude of PAD if and when present.

The participants who fulfilled the inclusion criteria were enrolled The ABI was then measured and calculated according to the HAP and LAP methods. The participants were then subjected to CCDU examination of the lower limb arterial circulation by two

independent investigators blinded to each other's findings and the ABI values. All the participants underwent CCDU and there were 42 of them who underwent angiography.

The limbs of the patients were assigned into groups according to the results of the ABI by high and low methods. This was done for the ease of description and classification. The limbs were considered rather than the patient itself because of the reason that a patient may have two differing values of the ABI on both therefore having values of two distinct subgroups. There were groups of limbs according to the ABI values of HAP method and LAP methods. They are as follows: (1) group I = subjects with normal ABI (0.9 – 1.3) by both methods; (2) group II = subjects with ABI < 0.9 by both methods; (3) group III = subjects with ABI < 0.9 by LAP method but not by HAP method; (4)group IV = subjects with ABI > 1.3 by both methods; (5)group V = subjects with ABI > 1.3 by HAP method and ABI 0.9 – 1.3 by LAP method and (6) group VI = subjects with ABI > 1.3 by HAP method and ABI <0.9 by LAP method.

Upon correlation of the ABI values wit the findings of CCDU there were 12 subgroups of limbs that were obtained. They are as follows: (1) subgroup I A – ABI 0.9-1.3 by both methods and with no evidence of PAD on CCDU, i.e. true negative for PAD; (2) subgroup IB – ABI 0.9-1.3 by both methods but with positive evidence of PAD (haemodynamically relevant, flow limiting stenosis) on CCDU, i.e. false negative for PAD (3) subgroup IIA – ABI <0.9 by both methods and with positive evidence of PAD by CCDU, i.e. true positive for PAD by both methods; (4) subgroup IIB – ABI <0.9 by both methods but no evidence of PAD by CCDU, i.e. false positive for PAD by both methods; (5) subgroup IIIA – ABI <0.9 by low method but >0.9 by high method with positive evidence of PAD by CCDU, i.e. true positive for PAD by LAP method but false negative by HAP method; (6) subgroup IIIB – ABI <0.9 by low method but >0.9 by high method with positive evidence of PAD by CCDU, i.e. false positive for PAD by LAP method but true negative for PAD by HAP method;(7) subgroup IVA – ABI > 1.3 by both methods with evidence of PAD by CCDU; (8) Subgroup IVB – ABI > 1.3 by both methods with no evidence of PAD by CCDU; (9) subgroup VA – ABI > 1.3 by HAP method but ABI 0.9 – 1.3 by LAP method without evidence of PAD on CCDU; (10) Subgroup VB – ABI > 1.3 by HAP method but ABI 0.9 – 1.3 by low method positive for PAD on CCDU; (11) Subgroup VIA – ABI > 1.3 by HAP method but ABI

<0.9 by low method positive for PAD on CCDU and (12) Subgroup VIA – ABI > 1.3 by HAP method but ABI <0.9 by low method without evidence of PAD on CCDU.

Categorical variables were expressed in absolute numbers and percentages. Continuous variables were described by absolute numbers, percentages and interval scales. Pearson's method was used to express the coefficient of correlation between two variables. Contingency tables to derive measures such as prevalence, sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios, diagnostic odds ratio and kappa measure of agreement. Those were the measures used to validate both the methods individually. In order to compare results obtained from HAP and the LAP methods (which were correlated proportions) the McNemar test was used.

Of the 432 limbs of 216 subjects there were 232(53.7%) limbs in group I. Group II had 125 (28.93%) limbs. There were 48 (11.11%) limbs in group III. Group IV and it was represented by 11(2.55%) limbs. Group V had 12 (2.77%) limbs. Group VI comprised of 4 (0.93%) limbs.

After correlation with the findings of CCDU, Subgroup IA had 221 (51.16%) limbs. Subgroup IB had 11 (2.55%) limbs. There were 123 (28.47%) limbs that belonged to subgroup IIA and subgroup IIB had 2 (0.46%) limbs. Subgroup IIIA had 45 (10.42%) limbs and subgroup IIIB had 3(0.69%) limbs. There were 8 (1.85%) limbs in subgroup IVA. Subgroup IVB had 3 (0.69%) limbs. There were10 (2.31%) limbs in subgroup VA. Subgroup VB consisted of 3 (0.69%) limbs. Subgroup VIA had 4 (0.93%) limbs. Subjects with normal or decreased ABI (groups I to III) formed the majority, i.e. 405 (93.75%) of the limbs. The limbs belonging to groups IV, V and VI were not considered in the validation of the methods.

The prevalence of PAD in this study was 44.2% by both methods. The sensitivity of HAP method was 68.72% and that of the LAP method was 93.85%. This difference in sensitivity is definitely significant. The specificity of HAP method was 99.12% and the specificity of the LAP method was 97.79%. Therefore there was no significant difference in the specificities of both methods. The positive predictive value of HAP method was 98.4% and it was 97.28% for the LAP method. The negative predictive

value of HAP method was 80% and the LAP method had a negative predictive value of 97.79%. The positive likelihood ratio for HAP method was 77.65 and for LAP method was 42.42. The negative diagnostic likelihood ratio was 0.3156 for the HAP method and 0.0628 for the LAP method. Despite a higher positive diagnostic likelihood ratio for the HAP method, the diagnostic odds ratio was 246.04 for HAP method and it was 675.48 for the LAP method. When McNemar test was used to compare the HAP and LAP methods it was demonstrated that LAP method was superior to the HAP method, with a P value < 0.0001 and this value is of very high statistical significance.

This study therefore demonstrated that the LAP method was far more sensitive than the HAP with almost no loss of specificity. On validation of both methods it was demonstrated that the LAP method was far superior in the detection of and in the assessment of haemodynamic magnitude of PAD. It was also found that when using the LAP method the ambiguities that arise in cases with elevated ABI could be minimised to a great extent. This study therefore has demonstrated that the LAP method is better in the detection of PAD than the HAP method (guidelines of AHA).