A NEURAL NETWORK FOR ESTIMATION OF AORTIC PRESSURE FROM THE RADIAL ARTERY PRESSURE PULSE

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Abstract. **A neural network is developed to estimate aortic pressure from the radial artery pressure pulse waveform. Invasively measured aortic and radial artery pressure in 51 adult subjects were used to train the network. Tests in a separate group of 21 subjects of similar age range showed a high correlation (r > 0.93) between measured and estimated systolic, diastolic and pulse pressure, with mean absolute errors (%) of 2.5±0.3, 3.5±0.6, 4.8±0.7 respectively. This method has potential applications in obtaining accurate estimates of central aortic pressure values from non-invasive radial artery pulse measurements. Such neural networks can be trained in specific subgroups (eg diabetics) to improve the estimation of central aortic pressure from the peripheral pulse.**
***Keywords* - Neural Network, Radial and Aortic Pressure, Transfer Function.**

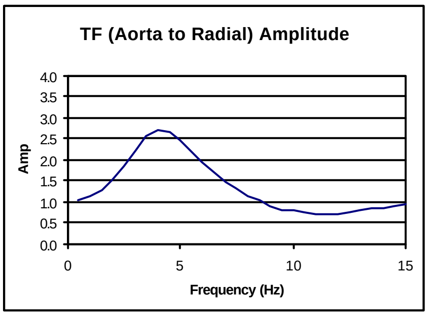

Fig 1 Amplitude of transfer function between aorta and radial artery.

I. INTRODUCTION

There is increasing interest in stratification of cardiovascular risk factors in subgroups of the population with emphasis on pulse pressure and central aortic pressure values [1]. The conventional measures of systolic and diastolic pressure in the arm do not give an accurate measure of pressure in the aorta because of the amplification of the pressure pulse as it propagates from the heart to the peripheral arteries [2,3]. However, since aortic pressure can only be measured essentially by invasive means, methods have been developed to estimate aortic pressure from non-invasive signals such as peripheral pressure waveforms, or simultaneous pressure and flow signals [4, 5-10]. One of these methods, the general transfer function method (GTF), relates aortic to radial pressure waveforms in the frequency domain (Fig. 1). This was obtained using invasive measurements and has been shown to be applicable in adults to estimate central aortic pressure from the radial pulse with reasonable accuracy [4,10].

While these general techniques take into account most of the morphological waveform changes, such as frequency depended amplification (Fig. 1), they do not account for additional effects of age or other conditions that may be specific to different risk groups [11]. This study attempts to apply neural network techniques to develop strategies for accurate estimation of central aortic pressure so that individual parameters are taken into account

II. METHODOLOGY

An artificial neural network is a mathematical representation of a real network in terms of neurons, function and connections. A neural network consists of neurons which relate multiple inputs to a single output using a mathematically defined function. All the inputs to the neuron are multiplied by variables called weights. Neurones can be arranged vertically in one layer and a neural network can have more than one layer (Fig. 2). In this case we will use a three layer neural network. The method involves a learning or training process where weights are changed according to a set of inputs and outputs using iterative methods. As a result, the weights will be such that it will produce the lowest error in the learning set. This type of neural network is described as a back-propagation network [12,13]

The inputs to the neural network in this study were age, height, weight, gender, heart period, radial systolic, mean and pulse pressure. These inputs were chosen since they are known influence blood pressure [3]. The outputs were aortic systolic and diastolic pressure.

Simultaneous invasive recordings of aortic and radial pressure waveforms were obtained for 72 subjects. A learning set was obtained in 51 subjects (16F, 35M, Age 38-84, Ht 150-189cm, Wt54-119Kg), and the test set in 21 subjects (2F, 19M, Age 39-76, Ht 156-185cm, Wt 60-119 Kg). Each recording was of about 10 to 12 pulses from which an averaged pressure waveform was calculated.

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Abstract

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From an investigation of different neural network structures (n=26), the final structure selected was one with 15 neurons in layer 1, 5 neurones in layer 2 and 2 neurones in layer 3, since this structure produced the lowest error of all those investigated.

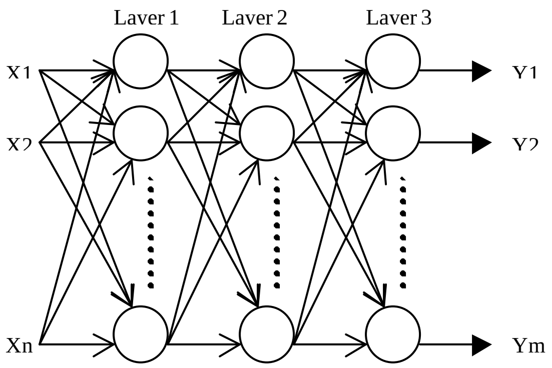

Fig. 2. Neural network with 3 layers and n input X and m outputs Y

III. RESULTS

Table 1 shows the low average error in aortic systolic, diastolic and pulse pressure produced by the neural network when used on the test set. Figs. 3,4,5 show the high correlation between the estimated and measured aortic pressure. R^2 for systolic, diastolic and pulse pressure are 0.94, 0.93 and 0.95 respectively.

TABLE 1

Error in % in estimating aortic pressure using neural network.

%	Systolic	Diastolic	Pulse
Mean ± SEM	2.5±0.3	3.5±0.6	4.8±0.7
Max	5	10.3	11.2

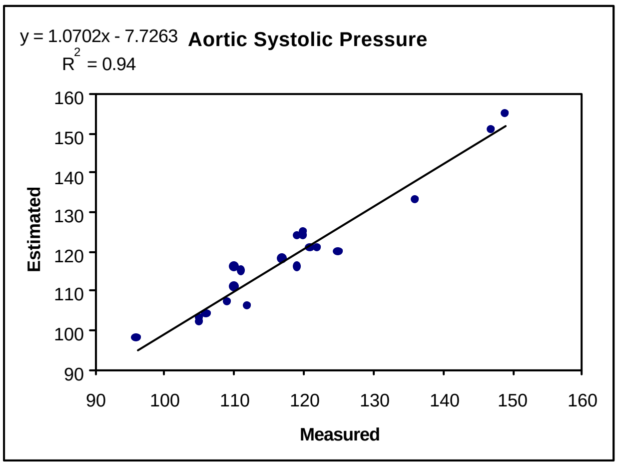

Fig 3. Estimated and measured aortic systolic pressure

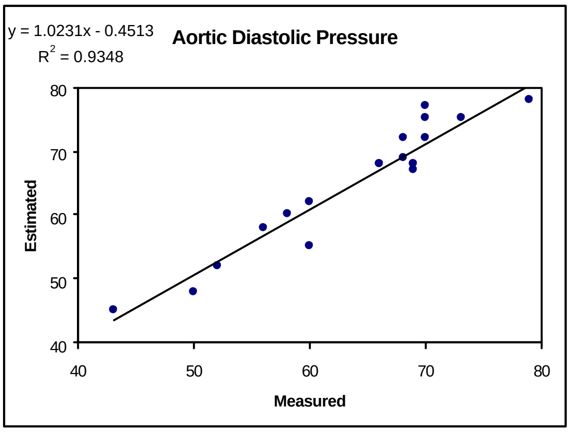

Fig 4. Estimated and measured aortic diastolic pressure

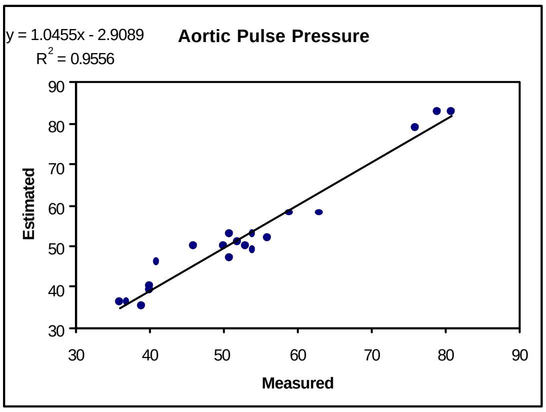

Fig 5. Estimated and measured aortic pulse pressure

IV. DISCUSSION

Neural networks can be trained to solve complex and non-linear problems where it is difficult to do so with conventional mathematical methods. Hence, because of the non-linear and complex inter-relationship between aortic and radial pressure, neural networks may be applied to estimations of central aortic pressure using a single input signal from a peripheral accessible site such as the radial artery.

This investigation has shown that a neural network can be trained in a group of subjects to derive aortic systolic and diastolic pressure values from a calibrated peripheral pulse. The neurons utilised a normalized sigmoid function of the form y = logSig(n), where n is the input and y the output with limits between 0 and 1. It has been shown that this function is efficient in converging to a minimum error [13].

As more invasive pressure measurements become available in subgroups of subjects with specific cardiovascular risk factors or disorders, the method can be refined to estimate weighting coefficients for that particular group. It will provide a complimentary method to the current methods employing the GTF Furthermore, this method can be developed to predict other aortic parameters related to the pressure waveform to provide a better non-invasive assessment of the cardiovascular system.

V. CONCLUSION

The results of this investigation show that neural networks have potential applications in obtaining accurate estimates of central aortic pressure values from non-invasive radial artery pulse measurements. Such neural networks can be trained in specific subgroups (eg diabetics) to improve the estimation of central aortic pressure from the peripheral pulse.

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