Targeting Blood Pressure by Monitoring Cerebral Autoregulation: Gradient Adjusted Flow-Pressure Curves

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Introduction: Cerebral blood flow is regulated over a range of systemic blood pressures through the Cerebral Autoregulation (CA) control mechanism [1]. The transcranial Doppler (TCD) based Mx measure has been proposed as a suitable proxy for blood flow in the analysis of CA [2]. Delineation of intact and impaired regions of autoregulation using Mx requires setting a minimum threshold above which the Mx measure is associated with impaired autoregulation [3]. This assumes that the gradient of the Flow-BP curve in the intact region is non-positive, which in practice is often not true. The method presented here allows for the enhancement of changes that occur between the intact and impaired regions of autoregulation, allowing a simple, automated algorithm to delineate the lower and upper limits of autoregulation (ULA/LLA).

Method: We used data from an in-house porcine study (N=9) that elicited blood pressure transitions to below the LLA. A linear regression between the TCD-based measure and MAP is calculated and used to subtract the values from the TCD-based signal. The gradient adjusted measure is calculated as

$$GA(x_i) = TCD(x_i) - y(x_i) \qquad [1]$$

where $GA(x_i)$ is the gradient-adjusted signal for the sample point x_i, $TCD(x_i)$ is the original TCD-based measure for the sample points x_i, and $y(x_i)$ is the value of the regression line for the same sample point. The method is fully explained in [4].

Results: Figure 1a shows the gradient adjustment technique applied to one of the animals in the study. It is very noticeable that in the top Mx plot there is not a clear-cut intact region, and traditional methods to segment the plot in intact/impaired regions would fail. The bottom plot depicts the same dataset after applying the GA method using a suitable Mx threshold. The transition zone between intact and impaired autoregulation is now obvious. Figure 1b shows box plots that includes the data for all the animals. The boxes for Mx above/below the LLA have a large overlap, and there is no large difference (0.149) between the median Mx values in both regions. In the boxes using the GA method, there is a clear difference (1.486) between the points above and below the LLA

Conclusions: The gradient adjustment method was successfully applied to a pig model to automatically evaluate the lower limit of autoregulation. There was a significant improvement in enhancing the transition zone between intact and impaired states. The gradient adjustment method appears to be a promising and simple to apply technique for evaluating the limits of autoregulation.

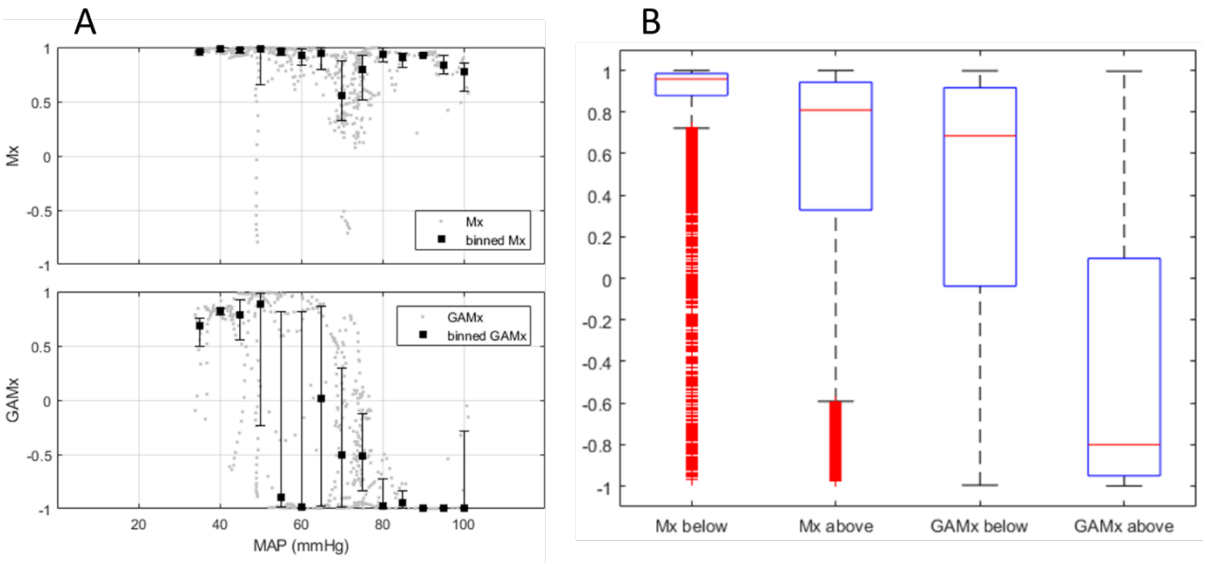

Figure 1. **A**: Mx and GA method applied on the Mx data for a single data set. **B**: box plots for all the animals for the Mx and GA method, separated in regions below the LLA and above the LLA. For the Mx data, median below LLA = 0.958, IQ: [0.880 0.985] and median above LLA = 0.809, IQ: [0.329 0.943]. For the Gradient-adjusted data, median below LLA = 0.686, IQ: [-0.037 0.917] and median above LLA = -0.800, IQ: [-0.950 -0.096].

References:

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