U-Shaped Bias in CPPopt: sources and solutions

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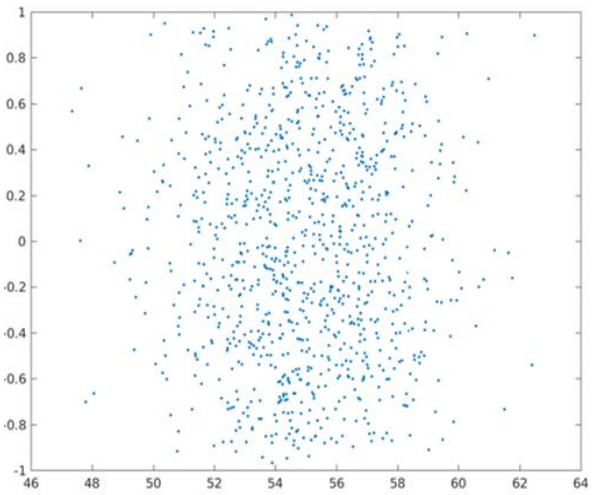
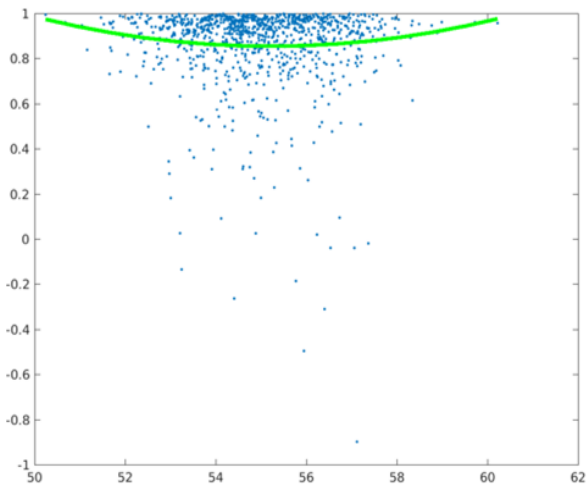
Intensive care management of traumatic brain injury hinges upon maintaining adequate cerebral perfusion pressure (CPP) in the face of raised intracranial pressure (ICP). There is some evidence that the choice of CPP target can be usefully individualised based on the optimising the state of cerebral autoregulation. An optimal CPP (CPPopt) can be calculated by plotting the pressure reactivity index (PRx), a marker of cerebral autoregulation, against CPP. Pressure reactivity index is the correlation co-efficient between MAP and ICP. Thus a positive PRx indicates poor cerebral autoregulation and vice versa. A curve is fitted to the CPP vs PRx data and the CPP at the minimum point gives the CPPopt where autoregulation is best preserved. However since PRx must lie between -1 and +1, we predicted that at more positive values of PRx a U shaped curve is more likely to be generated, a so called "ceiling effect". Therefore this CPPopt calculation is statistically biased to show an optimum value even when this does not exist. The Fisher Transformation has been used in the calculation for CPPopt in order to "normalize the data", but its necessity in removing the ceiling bias has not been explored. In this simulation we generate normalized random data to represent ICP and MAP and mimic the physiological situation by applying an autoregressive filter and varying degrees correlation between MAP and ICP. We show the presence of a "ceiling effect" at high levels of correlation and that this bias is removed via the application of the Fisher transformation. We therefore suggest that calculations of CPPopt are only unbiased if the Fisher Transform has been applied.



a) distribution of data when correlation coefficient = 0



b) "The Ceiling effect": a correlation co-efficient=0.9 produces a U shaped curve by distribution bias of the data

Figure 1: