MULTILEVEL MODELLING OF CORRELATED DATA TO SHOW IMPACT OF CAROTID ENDARTERECTOMY

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Cerebral autoregulation (CA) is an intrinsic mechanism of the body whereby a constant cerebral blood flow (CBF) is maintained to the brain, over a specific range of arterial blood pressure (ABP). A significant change in CBF, due to an increase or decrease in ABP indicates that CA is impaired.

Patients in this study suffer with carotid artery stenosis (CAS), a condition that disturbs CA. CAS is where the carotid artery is obstructed by atheroma; a build up of fatty plaque in the inner lining of the artery. All patients undergo a surgical procedure, Carotid Endarterectomy (CEA), in order to prevent transient ischemic attack or stroke. CEA is considered as a three phase procedure; before-clamp, clamp (when the atheroma is removed), and post-clamp. The aim of this study is to determine whether CA is improved following CEA. This will be assessed by investigating the change in CBF–ABP relationship from the before-clamp phase to post-clamp. A difference between before-clamp and post-clamp will indicate an impact of surgery. It is possible to examine the CBF-ABP relationship since there is spontaneous fluctuation of ABP expressed by the patient throughout the procedure, although the range of ABP will be limited.

Measurements of CBF and ABP, taken every 15 seconds, have been collected from 36 patients undergoing CEA. The three phases of CEA are recorded. The number of repeated measurements is not equal amongst phases or patients. A difficulty posed by this dataset is the high degree of correlation amongst the repeated measures, which makes standard linear modelling erroneous.

Inspection of CBF-ABP plots for this patient group reveals that the relationship is not a line with zero slope, as is expected in a healthy patient. Rather the relationship is generally approximately linear with a positive slope and steps between phases.

A multilevel model has been fitted, which acknowledges the clustering of repeated measurements within patient. ABP and Phase have been included as explanatory covariates at the lowest level. An AR(2) correlation structure was fitted for the error term, which is needed to account for correlated residuals at the lowest level and ensure a sufficient fit to the data, as is verified by residuals plots.

Results show that there is a positive change in intercept from before-clamp to post-clamp. This suggests success for CEA as there is improved CBF following surgery. There is a negative change in intercept from before-clamp to clamp. This means that CBF is reduced in patients during surgery, therefore close monitoring of patients is required here to ensure the brain is provided with an adequate blood supply to the brain. The model also shows there is no change in the phase slope, within patient. The slope is indicative of the level of CA in the patients. Therefore it seems that there is no immediate change in CA following surgery.

In conclusion, a multilevel model with correlated error structure provides a well-fitting model that aids in the description of changes in CBF as a result of CEA: CBF is increased but CA remains unchanged.