Behavioural state linkage and transition characteristics in the ovine fetus near term

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Objectives: In adult rats NREM sleep episode duration is positively correlated with preceding REM-sleep episode duration, supporting a homeostatic model whereby REM-sleep timing is controlled by accumulation of REM-sleep propensity during NREM sleep. We therefore sought to determine whether a similar relationship is evident for behavioural state activity in the ovine fetus near term, as a precursor to sleep-state development, and associated transition time characteristics with implications for underlying control mechanisms.

Methods: Nine fetal sheep were surgically prepared at 119-122 days gestation (term, 145 days) with placement of electrocortical (ECoG), electroocular (EOG), and nuchal muscle electrodes for monitoring behavioural state activity, and an arterial catheter for monitoring blood pressure/heart rate and selected blood sampling for blood gases/pH. Animals were studied four days later over an 8 hr period for the epoch duration and percent time in low-voltage (LV)/REM (ECoG amplitude <50 μv and EOG activity present), and high-voltage (HV)/NREM (ECoG amplitude >100 μv and EOG activity absent); and transition times between behavioural states. Behavioural state linkage was analyzed using group mean correlation coefficients, while behavioural state epoch duration and transition times were analyzed using group mean data (± SEM) with significance determined using paired *t*-test analysis.

Results: For the nine animals studied the mean epoch duration and percent time in LV/REM, at 14.8±0.8 min and 52±1%, respectively, was significantly greater than the corresponding values for HV/NREM, at 10.1±0.5 min and 36±1%, respectively (Both $p<0.01$). The mean transition time between LV/REM epochs and subsequent HV/NREM epochs, at 93±3 sec, was also significantly longer than the transition time between HV/NREM epochs and subsequent LV/REM epochs, at 78±6 sec ($p<0.05$). HV/NREM epoch duration was found to be positively correlated with the duration of the preceding LV/REM epoch duration with correlation coefficients for individual animals ranging from $r=0.14$ to 0.90, and a group mean correlation of $r=0.59$ ($p<0.01$). In addition, HV/NREM epoch duration was also positively correlated with the duration of the subsequent LV/REM epoch with correlation coefficients for individual animals ranging from $r=-0.41$ to 0.78, and a group mean correlation of $r=0.46$ ($p<0.01$).

Conclusion: The findings herein support a homeostatic model for LV/REM behavioural state timing as proposed for the adult rat, and moreover an interactive process between LV/REM and HV/NREM which may be of importance for the brain's growth and development. In addition, the faster transition time from HV/NREM to LV/REM favours active mechanisms for generation of the LV/REM behaviour state once the propensity for such reaches critical levels during the preceding HV/NREM state.