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The Crucial Role of Nerve Depolarisation in High Frequency Conduction Block in Mammalian Nerves: Simulation Study

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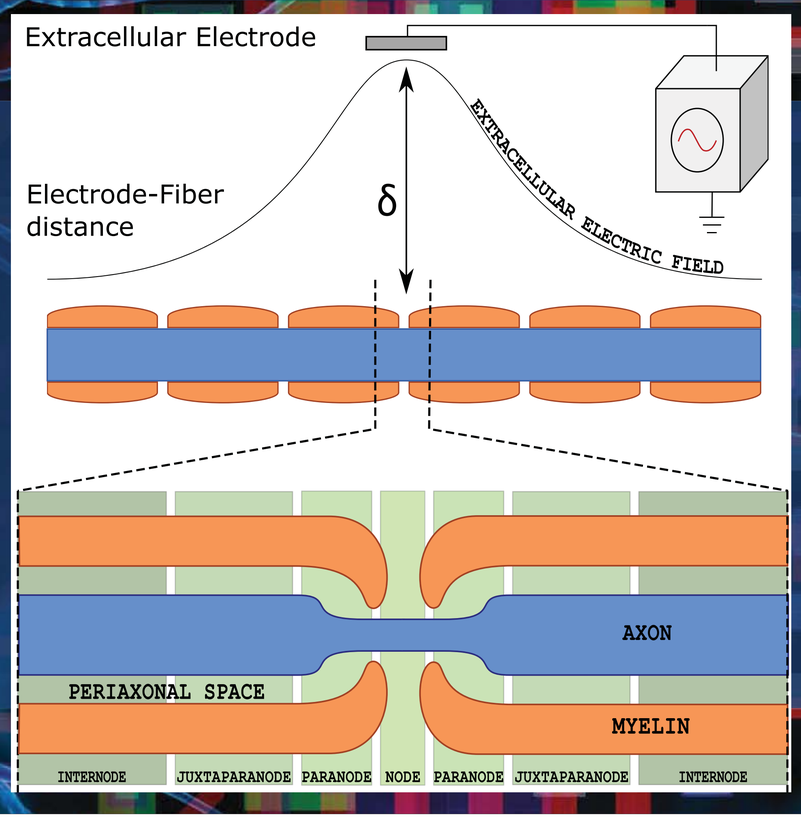
OVERVIEW

• High Frequency Alternating Current (HFAC) Nerve Block is used in therapy[1] yet not completely understood.

• Block in three different fiber sizes was simulated using the MRG[2] mammalian nerve model in the NEURON simulation environment.

• Mean paranode depolarisation between 24 and 30 mV was found to be a fiber size-invariant necessary condition for block.



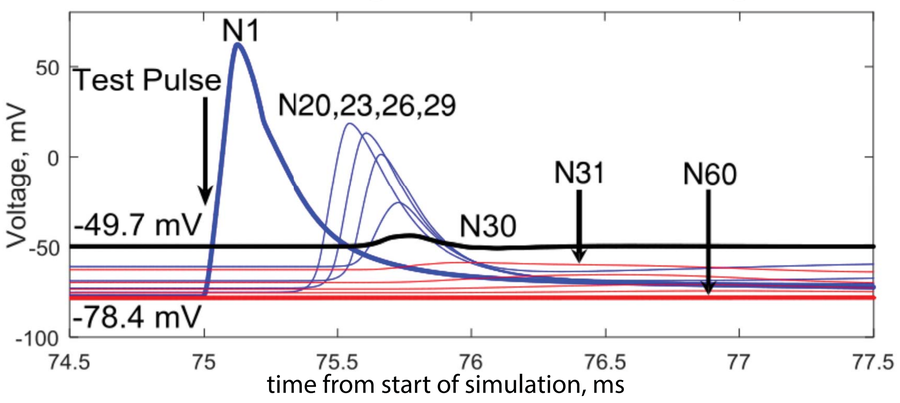
Methods and Analysis

• Achieving HFAC block depends on multiple parameters including amplitude, frequency and electrode-fiber distance[3].

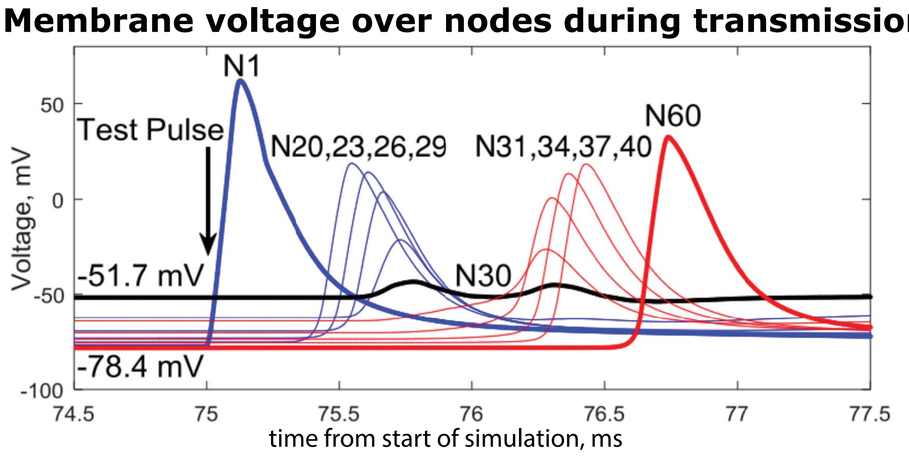
• Paranode voltage was monitored near the blocked node and averaged to obtain a signature of the nerve state for a set of parameters.

• Test pulses were sent at one end of the nerve and monitored at the other to evaluate the blocked or transmitting state of the simulated nerve fiber.

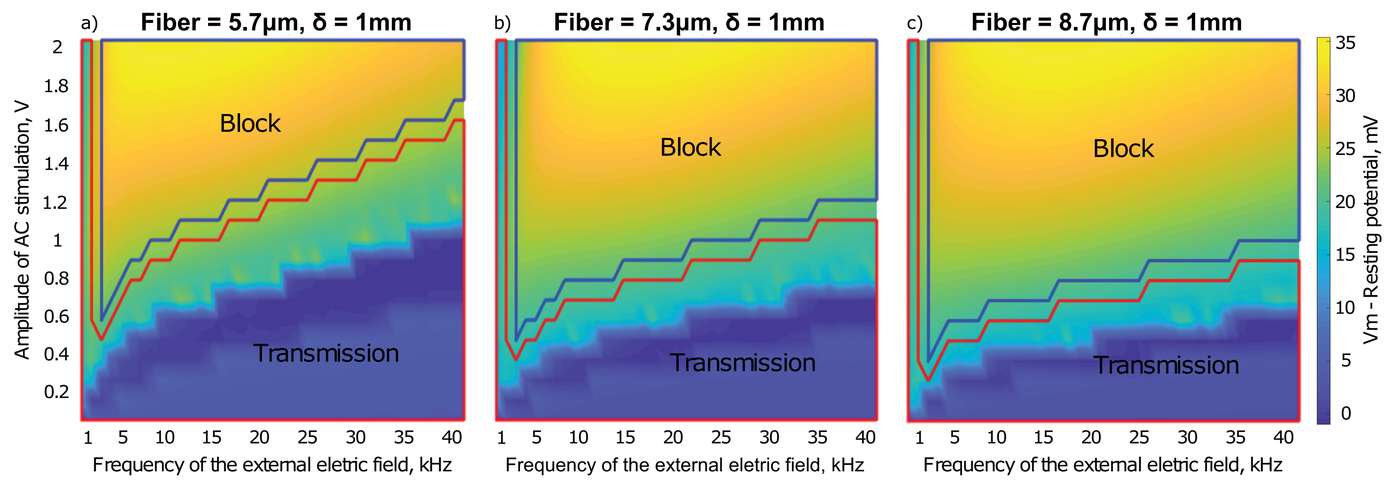
Membrane voltage over nodes during block



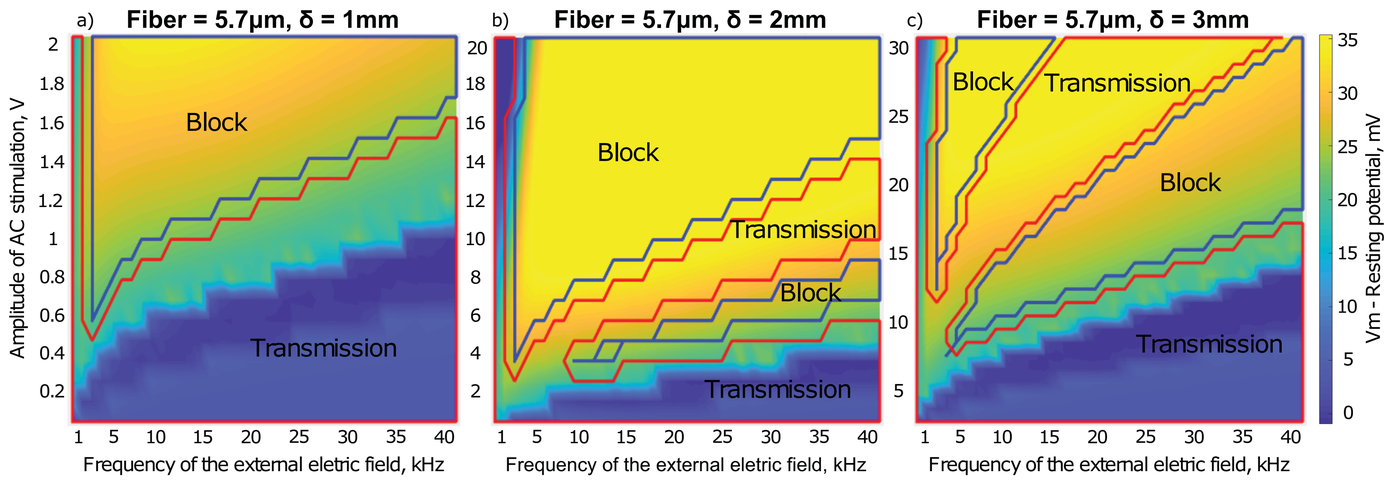
Membrane voltage over nodes during transmission



Effect of amplitude and frequency of blocking signal on nerve state



Effect of electrode-fiber distance on nerve state



Results and Conclusions

• Mean paranode depolarisation of 24-30 mV is necessary for block to occur irrespective of amplitude and frequency.

• Paranode depolarisation increases with amplitude but decreases with frequency, supporting how block thresholds rise with frequency.

• Greater electrode-fiber distances than 1 mm cause appearance of additional transmission regions beyond block threshold.

Further Work

• The secondary onset response is not captured by this model, however it is possible that it is caused by another mechanism with a longer time constant to reach a steady state.

• One candidate mechanism is ion diffusion during onset of the block and further work will simulate this aspect and study its effect on the onset response.

References

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[3] K. L. Kilgore and N. Bhadra, "Nerve conduction block utilising high frequency
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