Phase Simulation to assess vessel structure stenosis in Arteriovenous Malformation using MATLAB Simulation

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Agenda

• Cerebral Arteriovenous Malformation

• Proposed Solution

• Input Signal Combinations

• Phase Variations

• Results

• Conclusion
Cerebral Arteriovenous Malformation

- Normally, Arteries and veins are connected by capillaries.
- In CAVM - capillaries are absent resulting in tangled cluster of vessels.
Effect of CAVM

- Turbulent Flow

- Complex Vessels Structures

- Nidus structures combinations
- of multiple vessel abnormalities
Problem Statement

• Cerebral Arteriovenous Malformation (CAVM) is one of neurovascular disease.

• Current clinical procedure is for diagnosis and treatment procedure is invasive technique.

• The invasive technique is riskier to patients as CAVM get rupture.
Proposed Solution

• To replicate actual patient condition, we have simulated similar condition using Matlab simulation.

• Proposed non-invasive method to measure hemodynamics non-invasively using Simulink

• Using Matlab simulation lumped model is created and simulated using Signal combinations.

• The proposed model helps doctors to diagnose or treat CAVM disease.
Simulated signals are generated with combinations of multiple signal builder. This represents pressure variation inside brain.

The input is varied for magnitude and phase variations.
Simulated Cerebral Signals using Matlab

Represent different brain pressure variations to replicate actual patient condition
Phase Variations

• The input signal is varied for magnitude and phase variation.

• The signals are simulated by varying for both constant magnitude and varying phase analysis & constant phase with varying magnitude.
Network Creation

• The network creation is based on Windkessel Model.

• The clinical parameters are converted to electrical network.

• The value of each components-R,L,C are derived from vessel diameter and type of network formation based on vessel diameter size.
Simscape-Snapshot of model
Results - Clinical Findings

• The magnitude of stenosis node behaves differently from its neighboring node. The voltage decrease from normal node to stenosis node is about 95% and node after stenosis node, the results shows the increase in the voltage, which is evident to differentiate the normal node and stenosis node.

• The phase angle for the disease node gave clear differentiator for pvalue from other nodes, where pvalue is less than 0.05 (pvalue <0.05) represents the stenosis node, for the other node the pvalue is very high.

• The results shows that for any type of signal variation, whenever there is a change in the diameter in vessel, if the pvalue of phase angle for any node is less than 0.05, that node is detected as stenosis node in CAVM vessel structure.
Conclusion

Successful detection of vessel abnormality node in a complex vessel structure using Matlab phase simulation.

Phase analysis helps in early detection of vessel disease, helps clinicians for appropriate steps for diagnosis and therapy.