Cerebral blood flow: possible hemodynamic links between atrial fibrillation and cognitive decline

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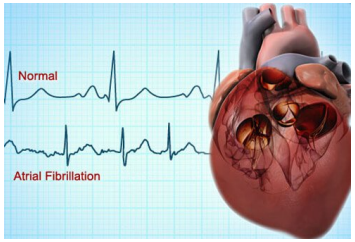
Background & State of the Art

- Atrial fibrillation (AF)
  - Common arrhythmia: irregular and faster beat;
  - 33.5 million people worldwide in 2010 (to be doubled in 40 years);
  - Disabling symptoms and reduced quality of life;
  - $ 6.65 billion/year in the USA (2006);



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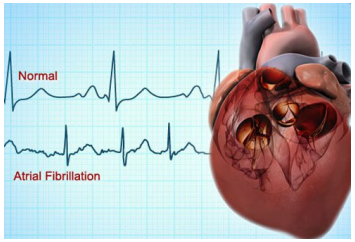

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  - Neurological degeneration: loss of memory, socio-cognitive alterations;
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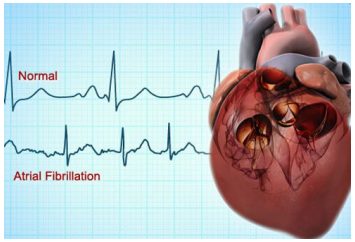

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- Recent independent association between AF and dementia
  $\Rightarrow$ Potential hemodynamic mechanisms: microembolisms, altered cerebral blood flow, hypoperfusion and microbleeds.

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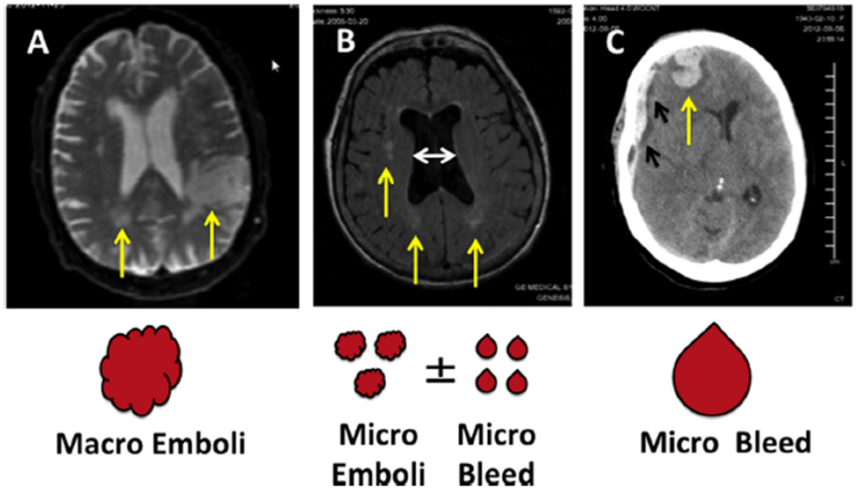

Spectrum of macro- to micro-cerebral injuries from AF (*Jacobs et al., 2015*)

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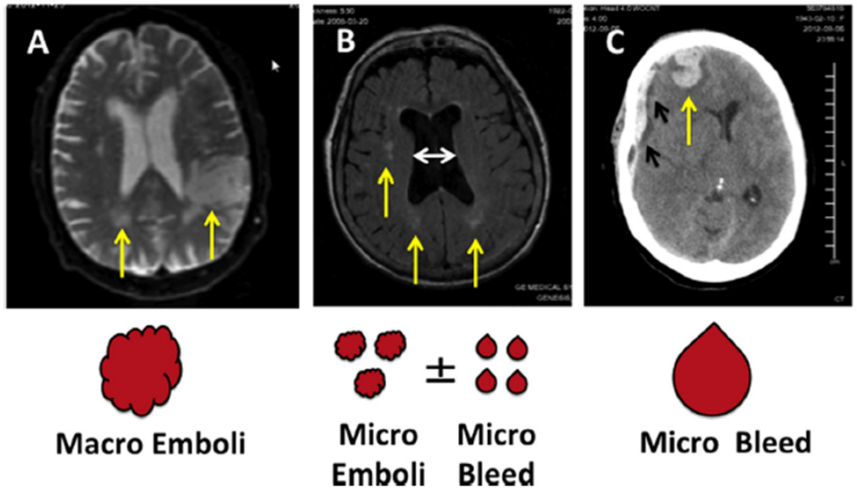

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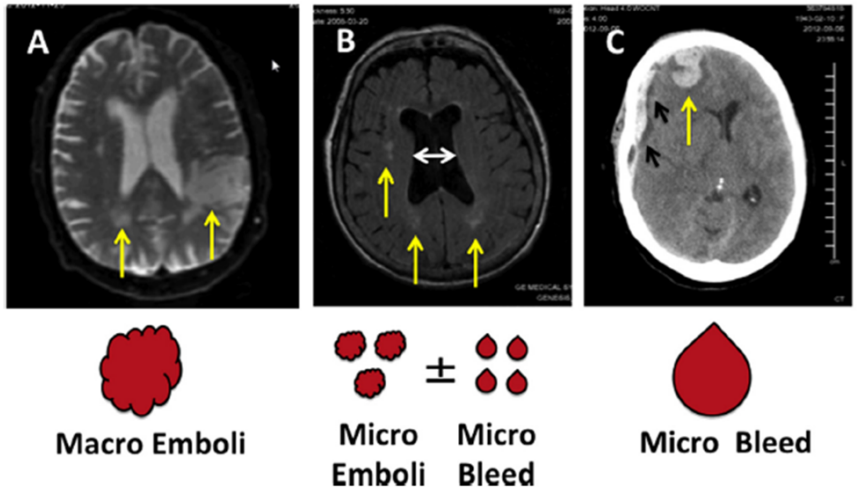

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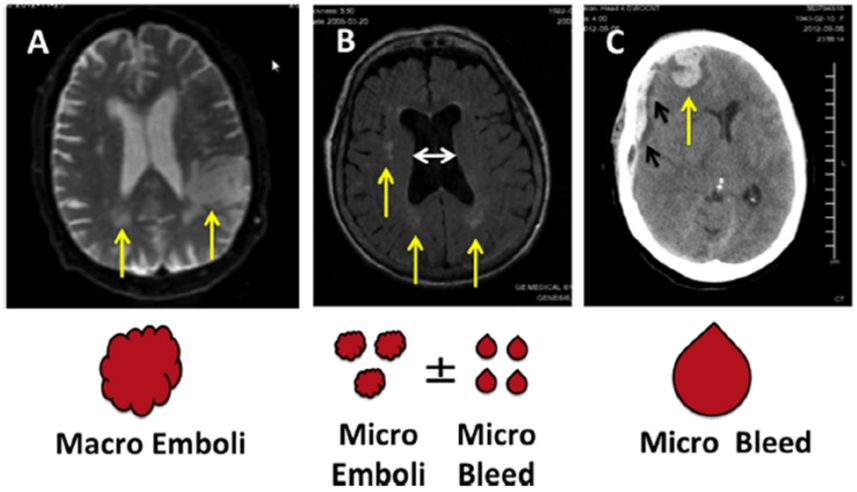

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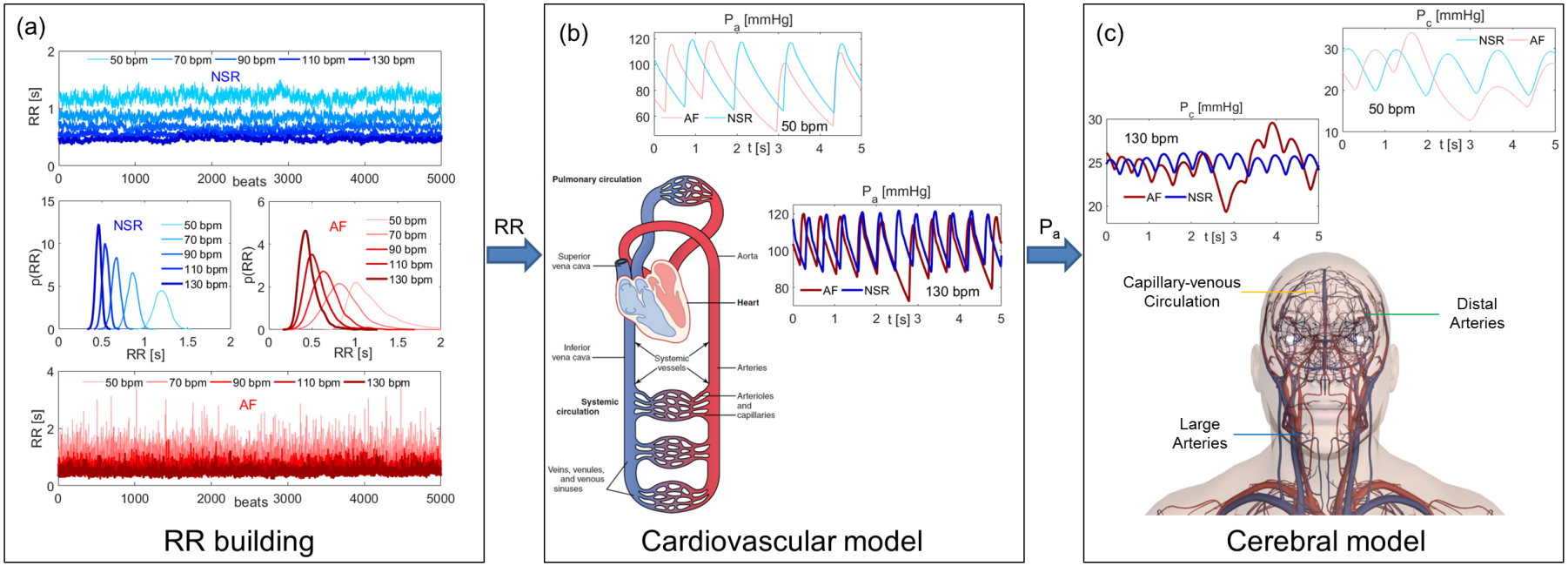
  $\Rightarrow$ Impact of heart rate (HR) during AF on cerebral hemodynamics

Methods: Computational algorithm



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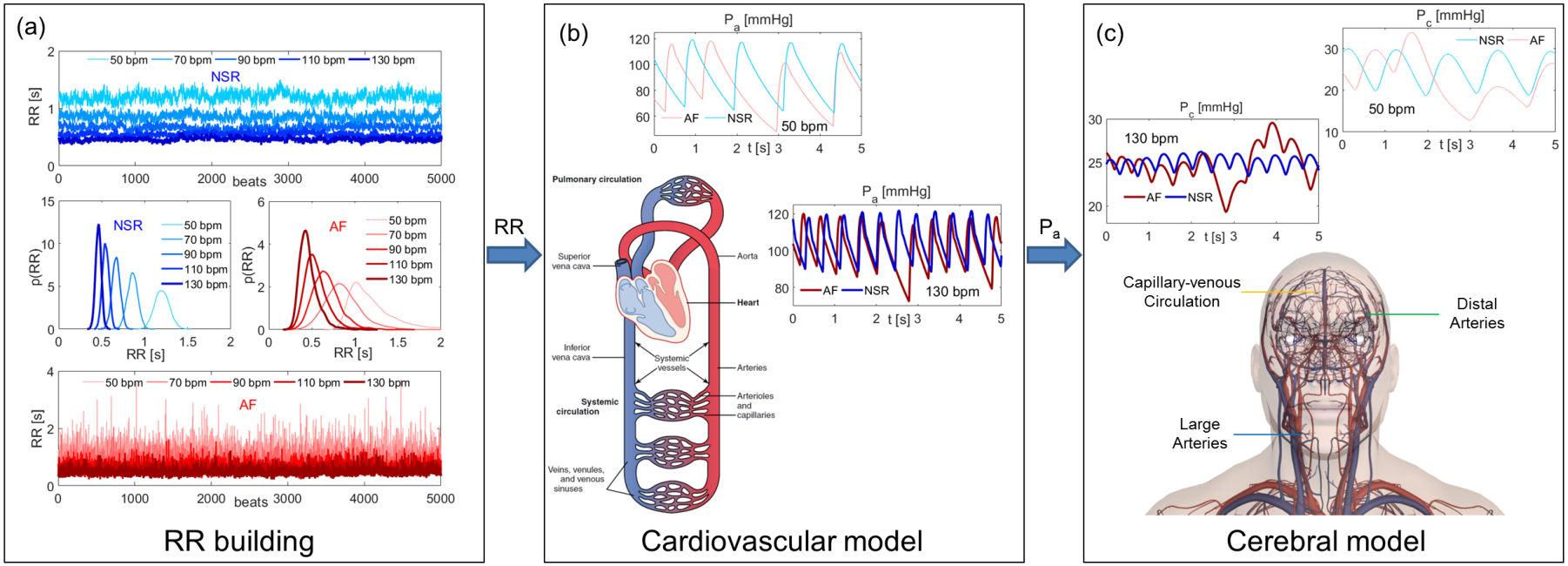

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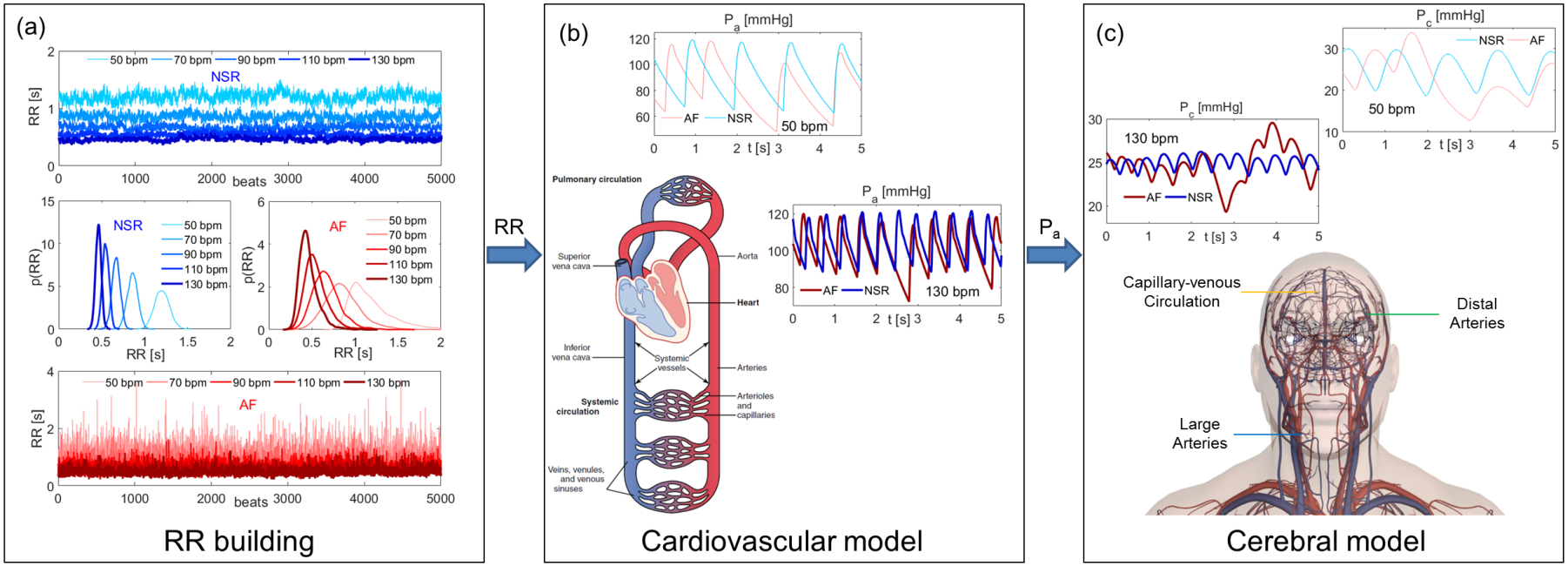

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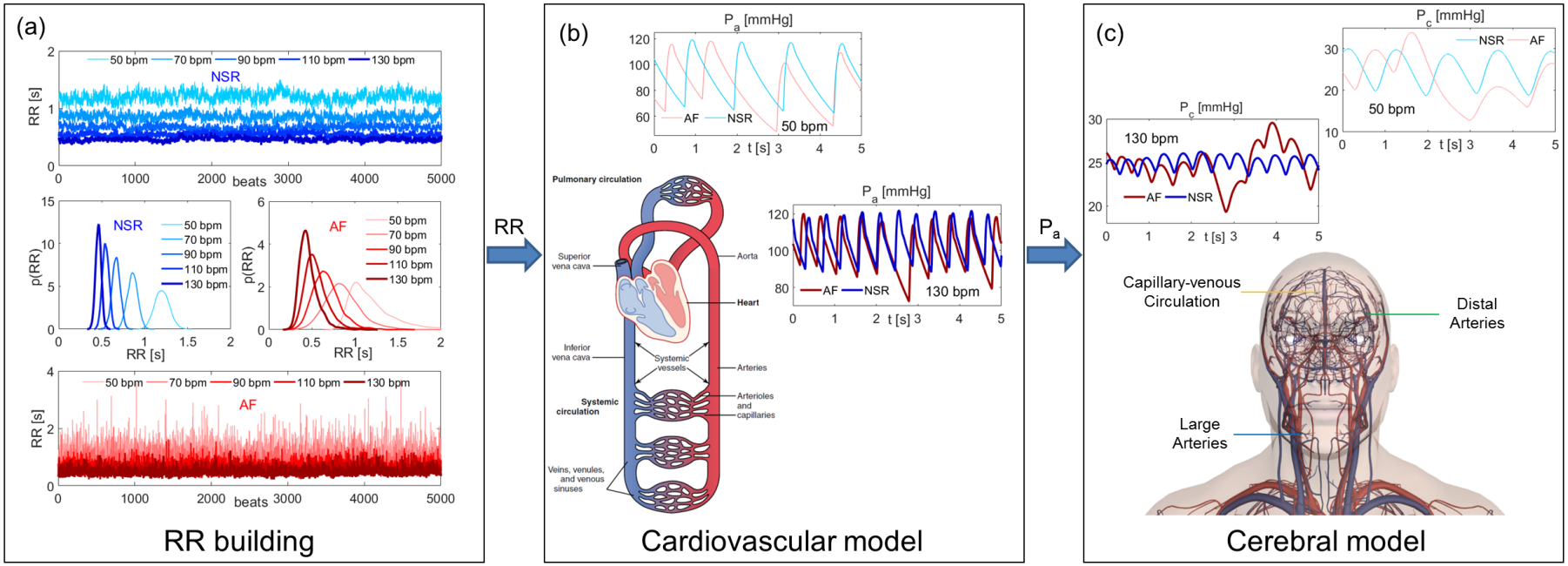

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- Focus on the proximal-to-distal pathway (left side):
  - Large arteries (P_a, $P_{MCA,left}$, $Q_{ICA,left}$, $Q_{MCA,left}$);
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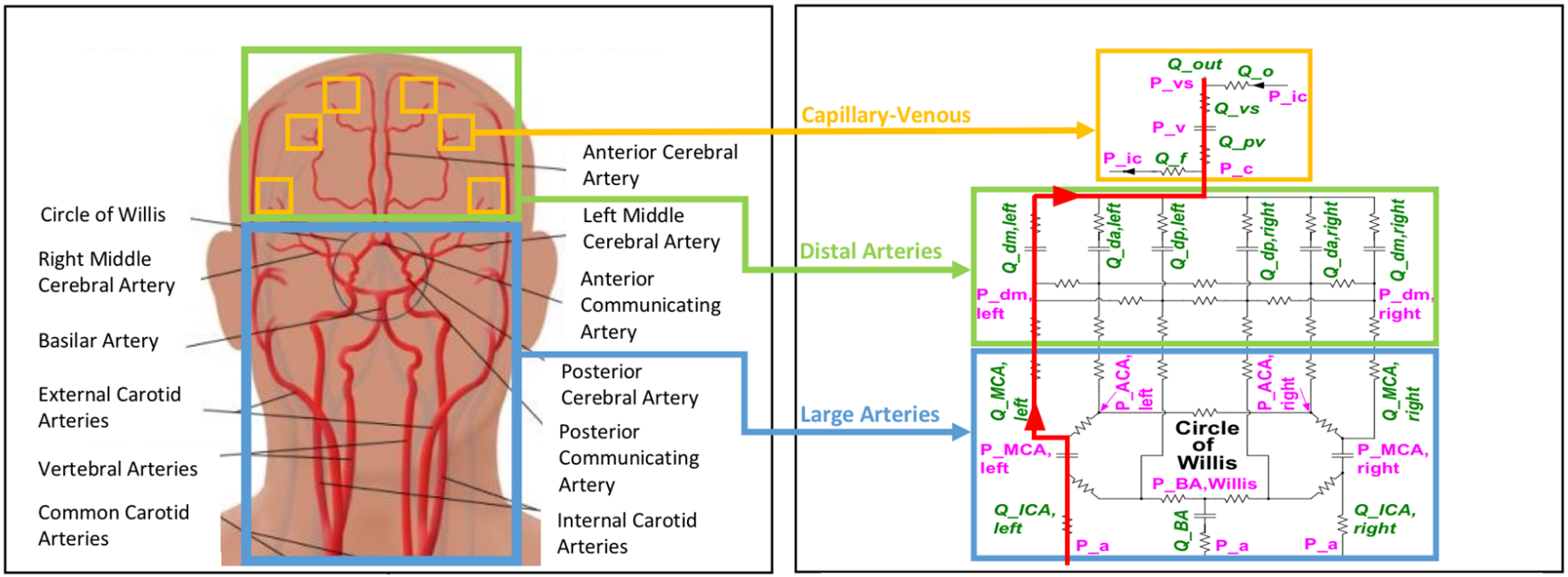

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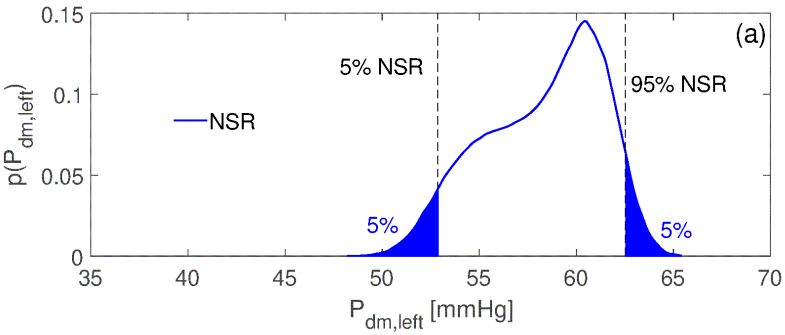
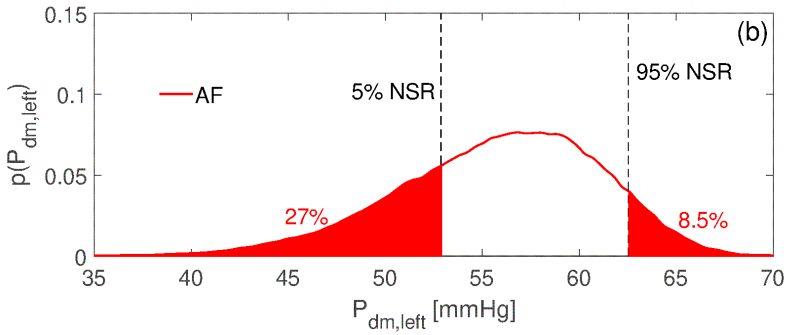
Methods: Data analysis

- Percentile evaluation





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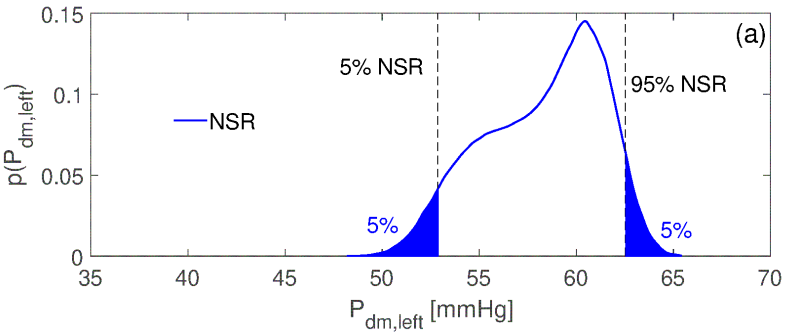
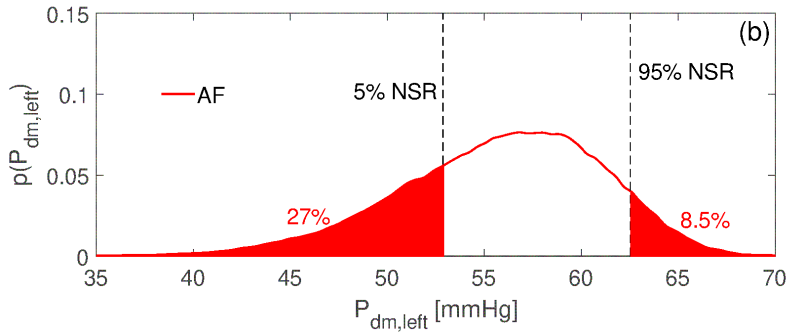
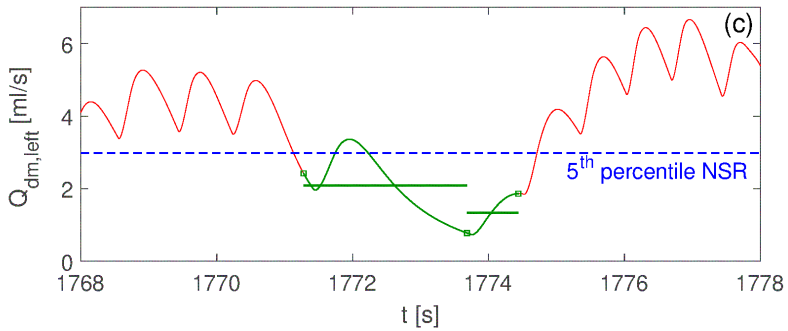
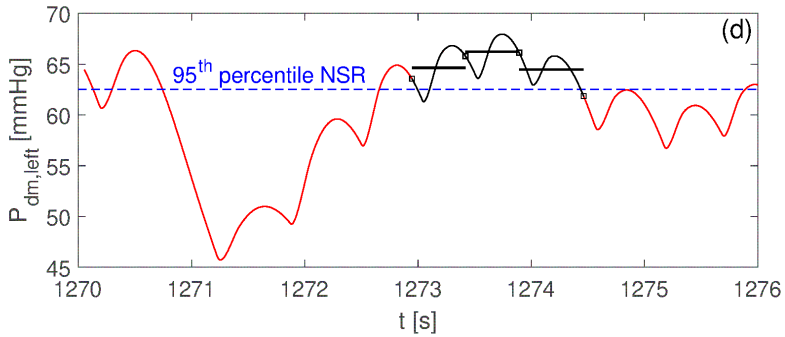


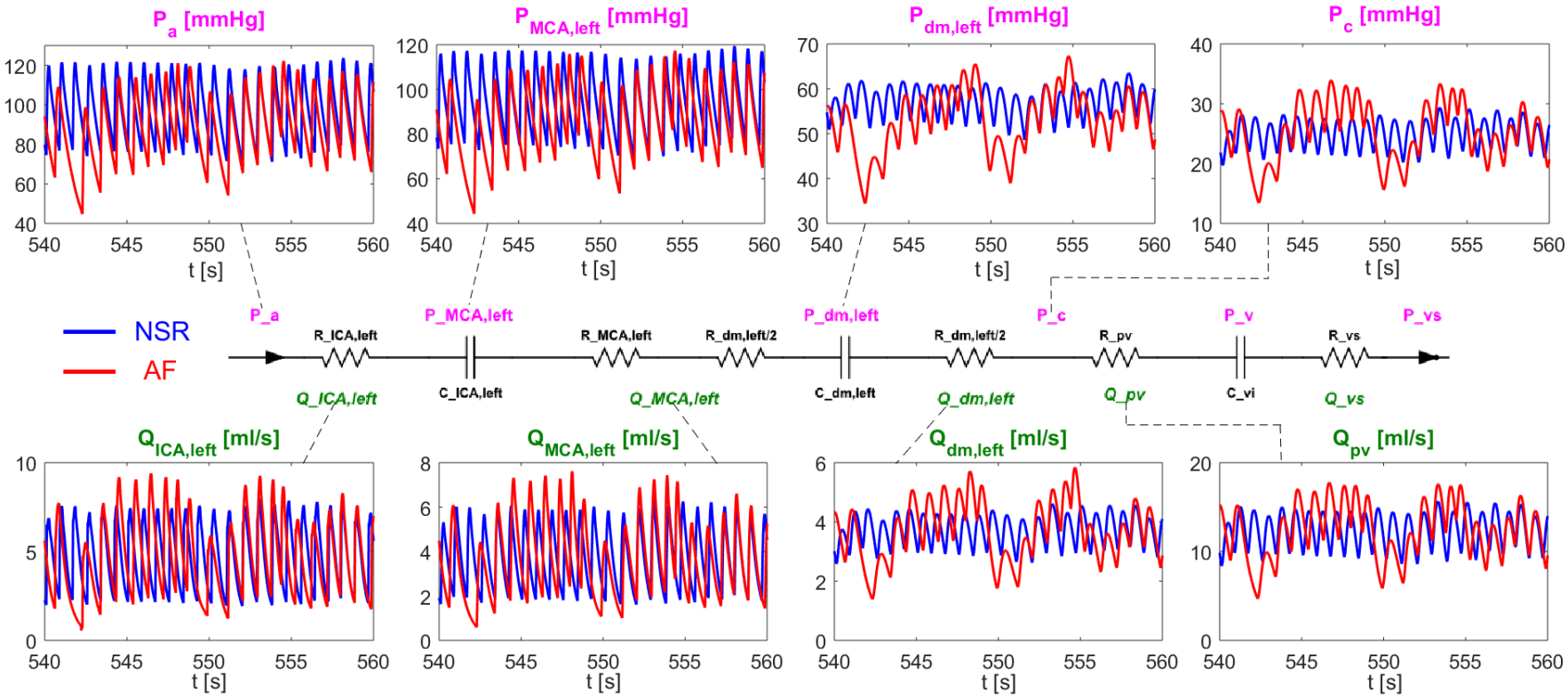


- Recurrence of extreme events (hypoperfusions and hypertensive events) in AF





Results: proximal-to-distal pathway



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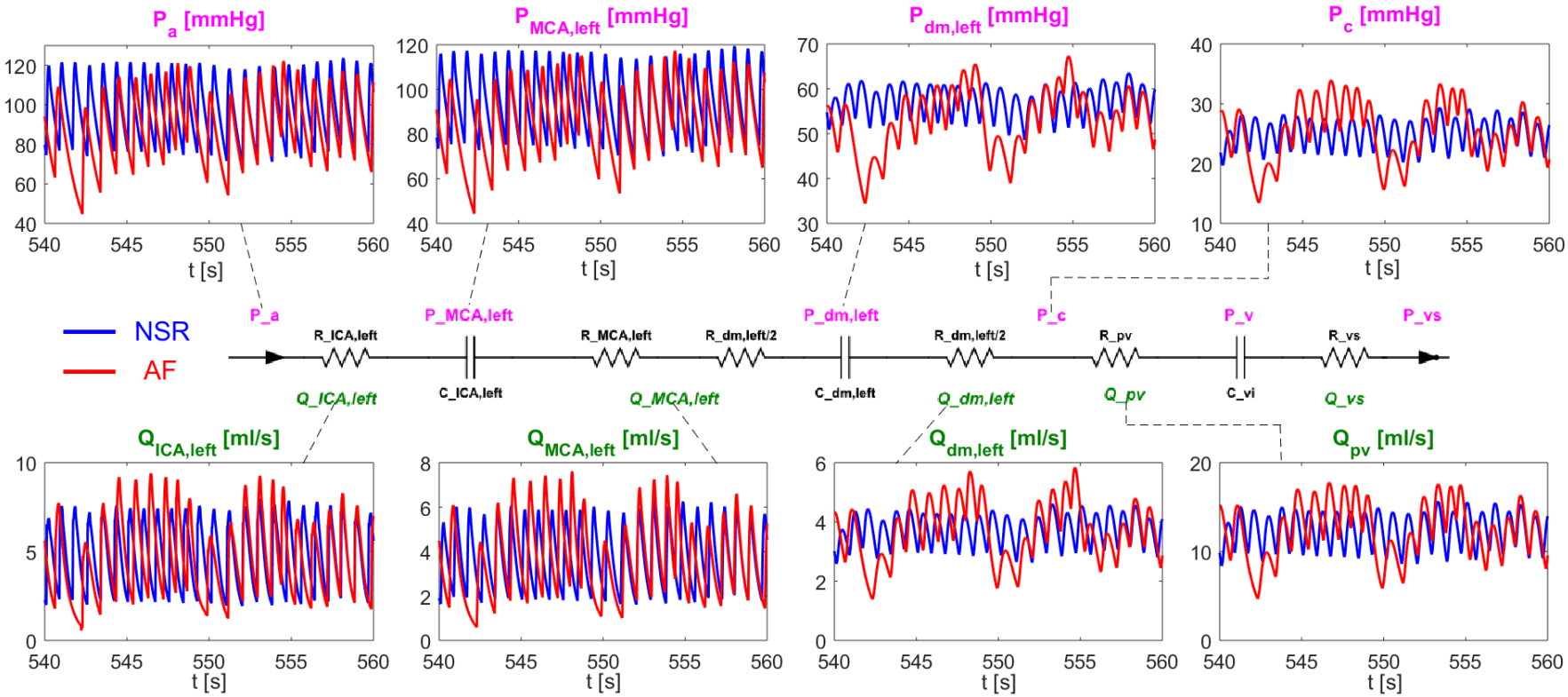
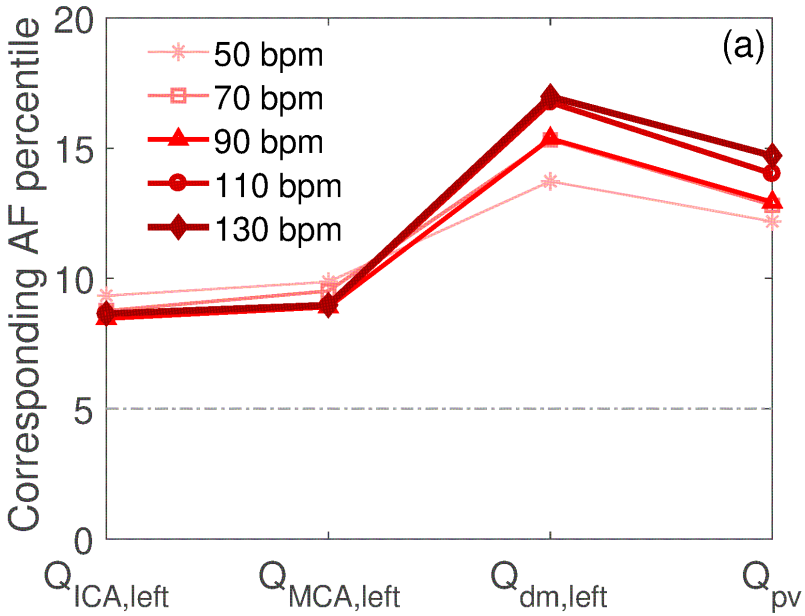
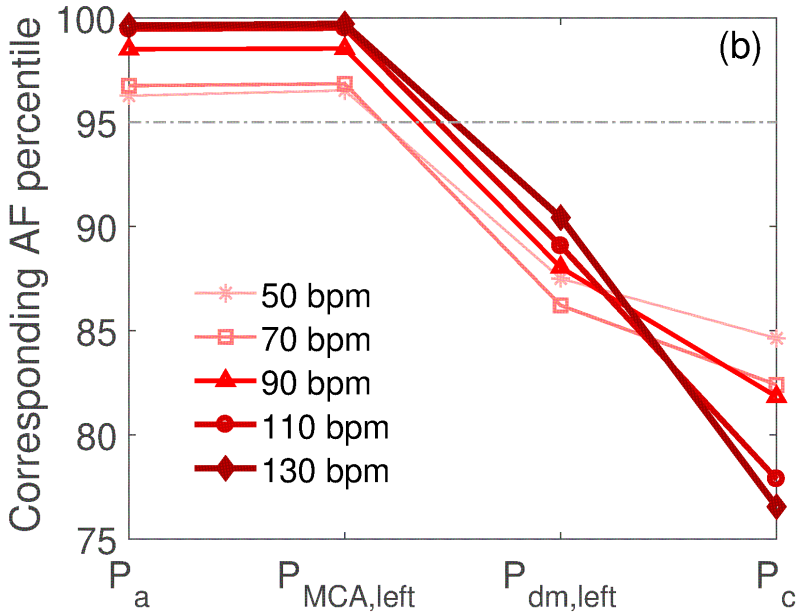


- HR=70 bpm. Compared to NSR, AF triggers a higher variability of the cerebral hemodynamic variables, increasingly proceeding towards the distal circulation.

Results: percentile analysis





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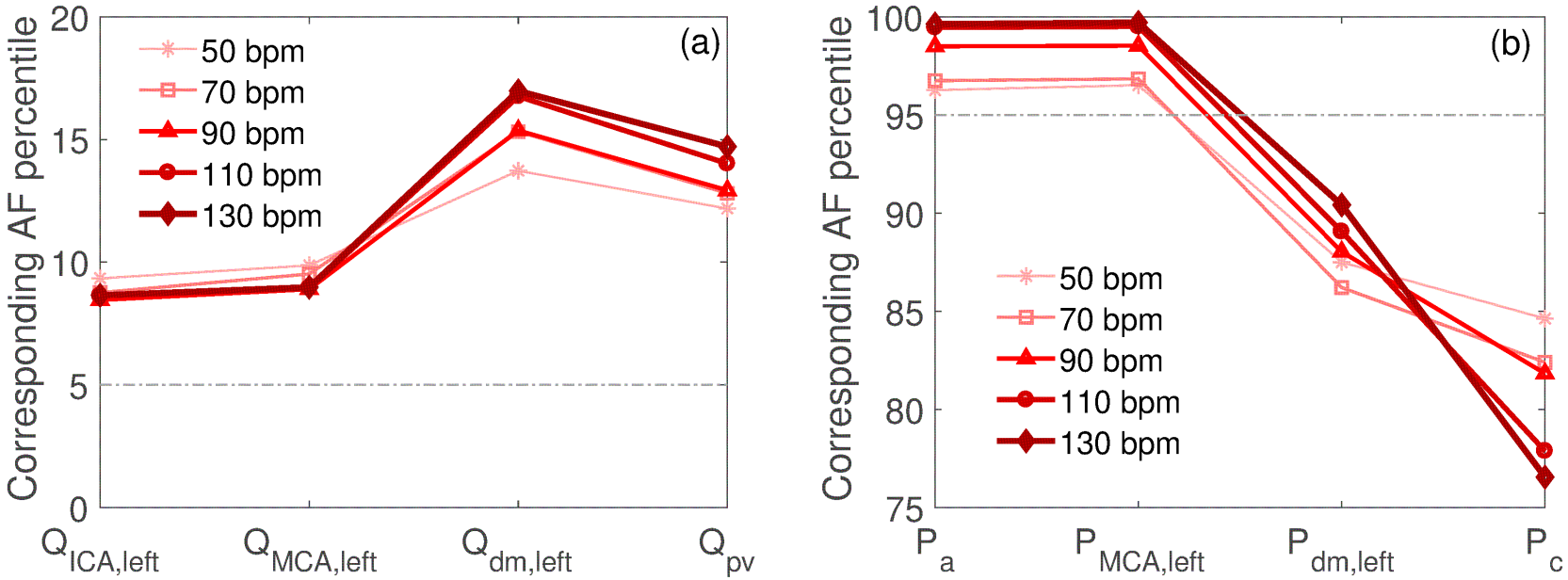
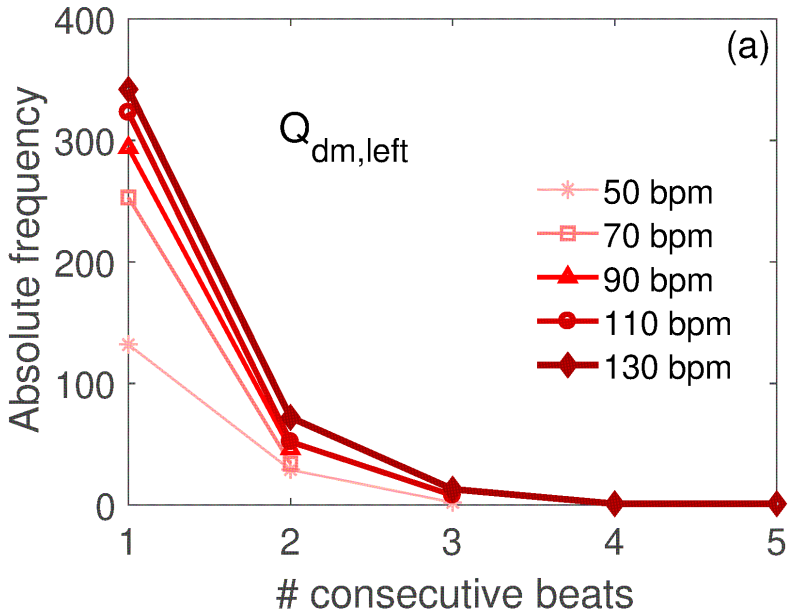
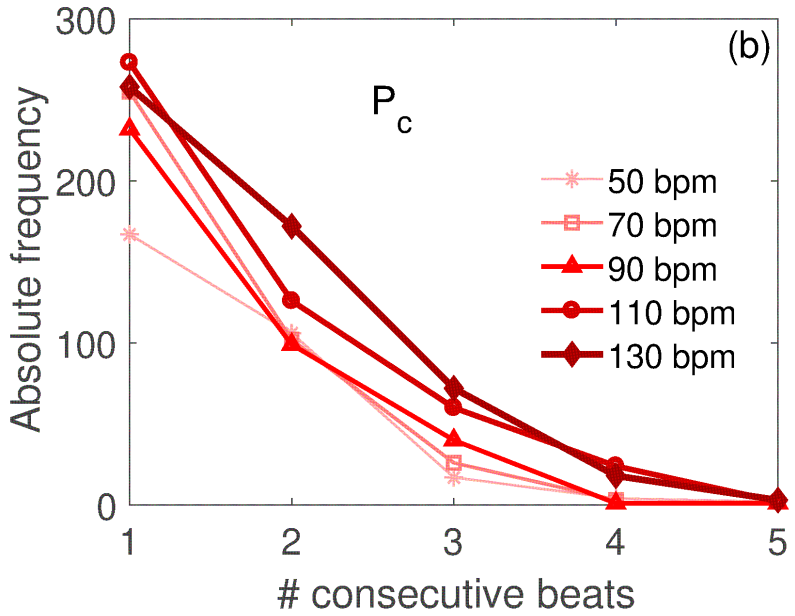


- The increased variability during AF leads to critical hemodynamic events of reduced blood flow or excessive pressure in the deepest cerebral circulation (arterioles and capillaries).

Results: hypoperfusions and hypertensive events





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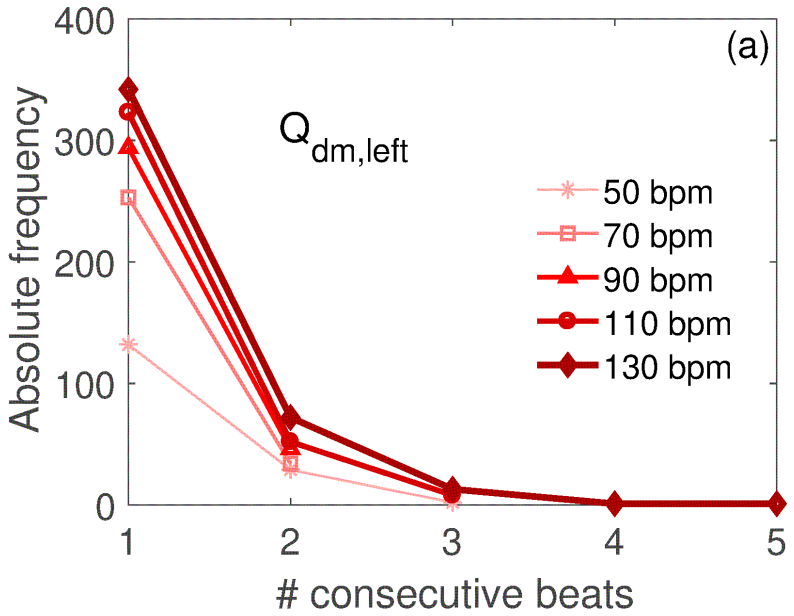

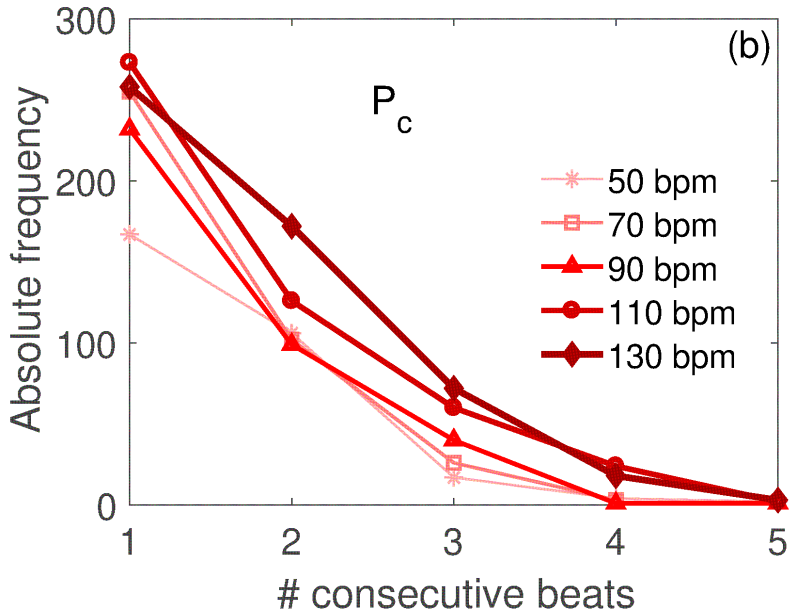

- Absolute frequency over 5000 beats of (a) hypoperfusions ($Q_{dm,left}$) and (b) hypertensive events (P_c) during AF.

Results: total number of one-beat extreme events

Hypoperfusions				
	$Q_{ICA,left}$	$Q_{MCA,left}$	$Q_{dm,left}$	Q_{pv}
50 bpm	1	2	196	124
70 bpm	0	0	321	136
90 bpm	0	0	386	216
110 bpm	0	0	451	352
130 bpm	0	0	534	415
Hypertensive events				
	P_a	$P_{MCA,left}$	$P_{dm,left}$	P_c
50 bpm	0	0	231	456
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- Critical events (over 5000 beats) mainly occur in the distal region (rare episodes in the proximal region) and increase with HR.

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