GETTING COMPUTER SIMULATIONS INTO THE CLINIC: On Pulmonary Hypertension Detection

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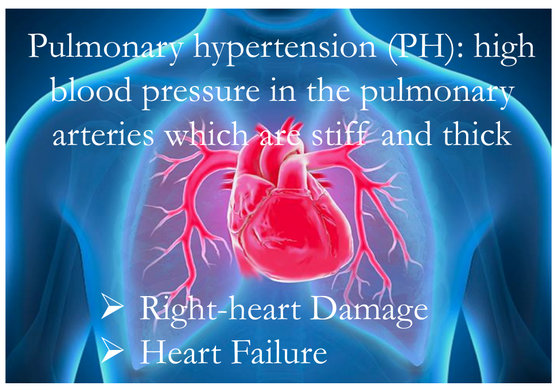
We use computational modelling to improve the diagnosis process for pulmonary hypertension.

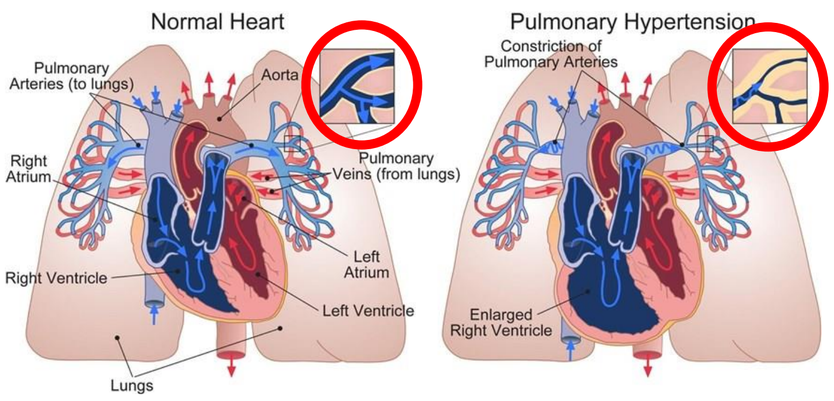
1 CONTEXT

" Respiratory diseases in the UK: third cause of death (20% of all deaths yearly) "

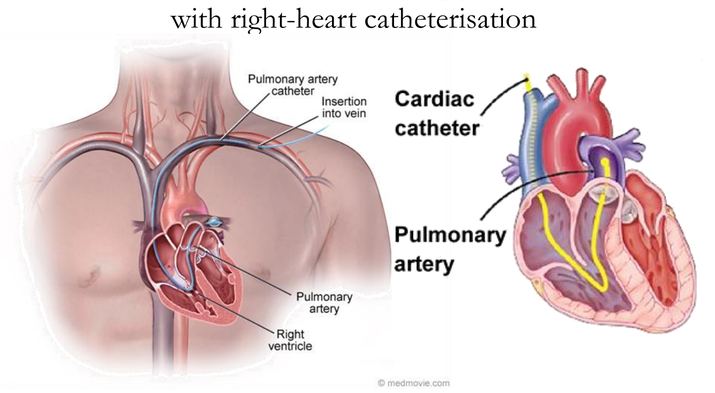
" £11 billion: annual economic burden of all lung conditions on NHS UK "

" Pulmonary hypertension: 70% of deaths from pulmonary vascular diseases "





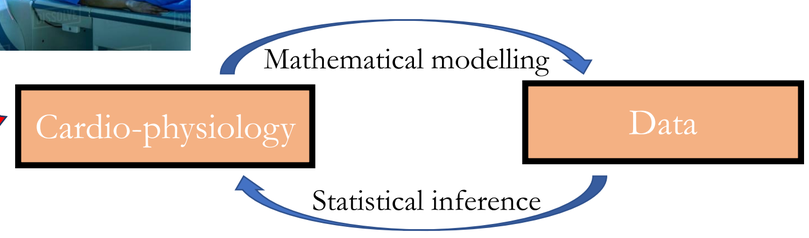
Diagnosed by **invasively measuring** pulmonary pressure with right-heart catheterisation

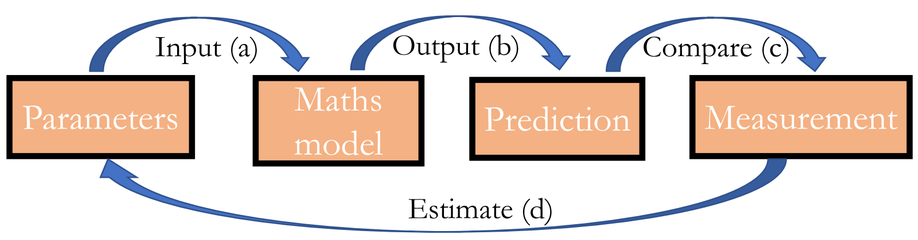


Aims (UK HEALTHCARE IMPACT*):

1) ***Use solely **non-invasive** procedures and **computational models** to predict pulmonary blood pressure.
2) ***Work towards a **clinical** decision system with reliable disease diagnosis in **real time**.
3) Develop a robust and computationally fast **statistical inference procedure** to assist mathematical modelling.

Magnetic Resonance Imagining (MRI)



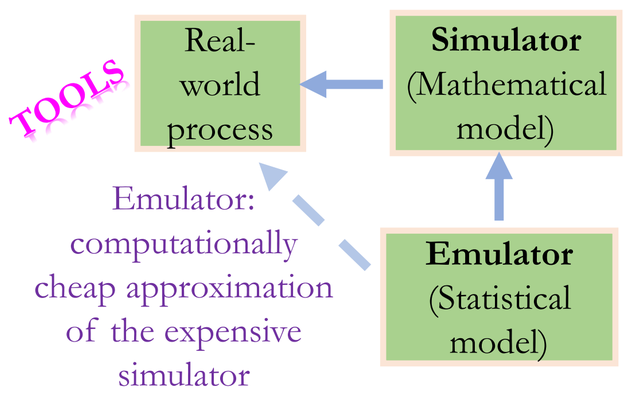


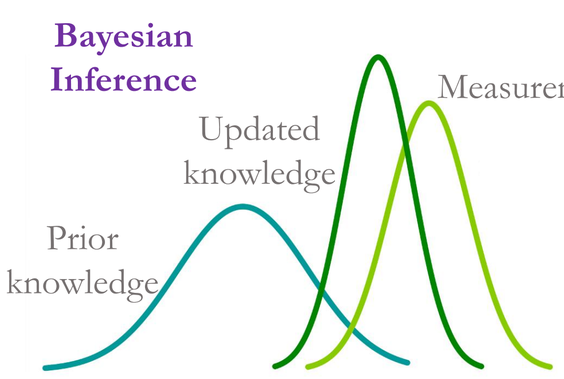
CHALLENGE

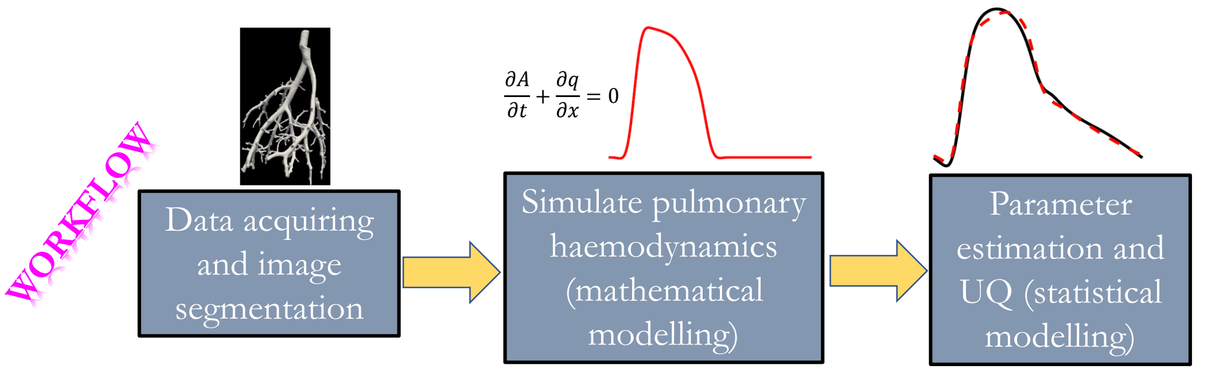
Prohibitive computational costs ... BUT parameter estimation and uncertainty quantification (UQ) are vital because biophysical parameters (e.g. vessel wall stiffness, increased during PH) have genuine predictive value for disease prognostication.

2 INNOVATIVE MODEL

Computationally fast state-of-the-art numerical methods to **estimate** unknown parameters from measured data & **predict** invasively-measured blood pressure.



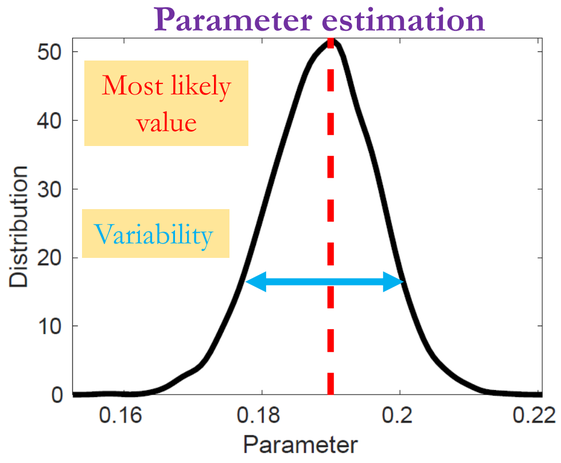




- **Match** model predictions to measured data to obtain likely parameter values
- Use **state-of-the-art** Bayesian numerical methods
- Approximate mathematical model to **reduce** computational costs

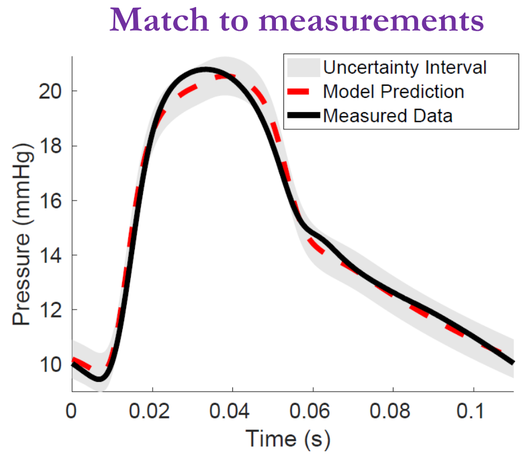
3 RESULTS AND CONCLUSIONS

Parameter estimation



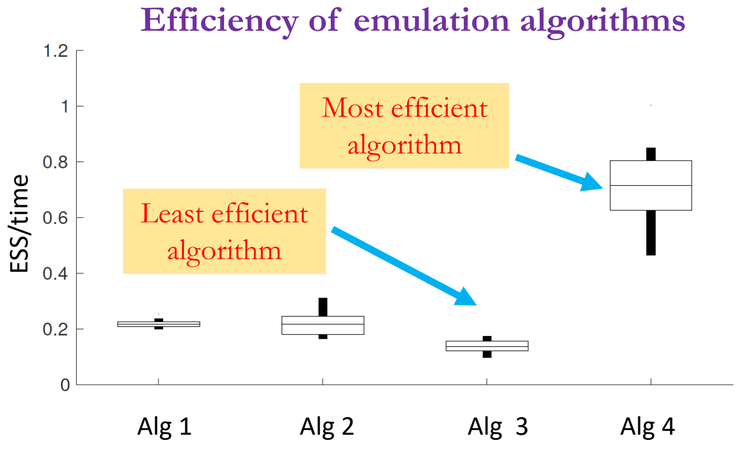
- Estimation and UQ of **biophysical parameters** relevant for PH diagnosis

Match to measurements



- Successfully **predict** measured data with novel statistical methods

Efficiency of emulation algorithms



- Focus on algorithm efficiency to allow **real time disease diagnostication**

Existing vs proposed method

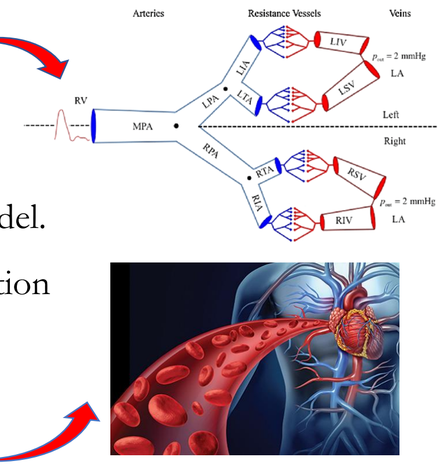
Method	Efficiency (ESS/no iterations)	Time elapsed
Reference (simulator)	4.5%	12 days
Proposed (emulator)	**60%**	**1 day**

- Highly **efficient** novel statistical method
- Running time highly **reduced**

ESS: Effective Sample Size

4 FUTURE STEPS

1) Incorporate the venous side in a more physiologically realistic mathematical model.
2) Investigate the effect of drug administration (for blood pressure reduction) on the parameter estimation.



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6 References

1. **Paun LM**, Qureshi MU, Colebank M, et al. MCMC methods for inference in a mathematical model of pulmonary circulation. *Statistica Neerlandica,* 2018 72: 306– 338.
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