

Numerical investigation into the effects of ageing on the air conditioning capacity of the human nasal cavity

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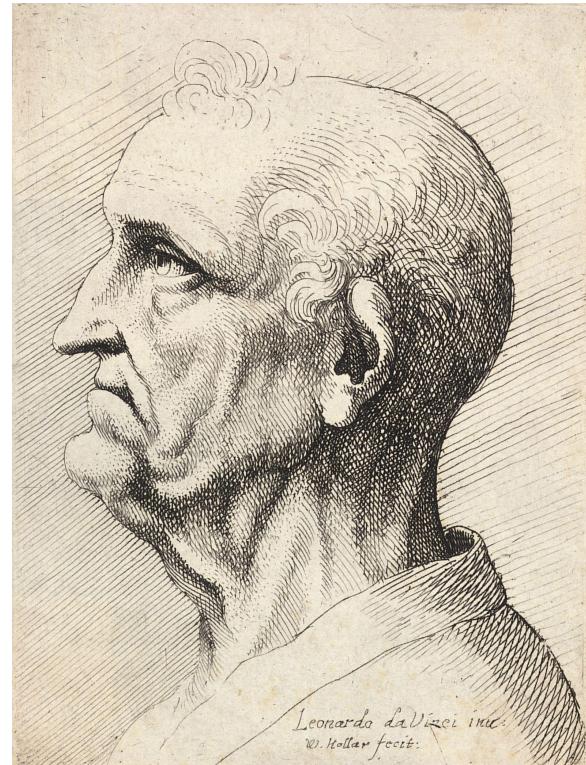
Outline

- **Background and literature review**
- Work up to confirmation of candidature
- Current work
- Future work
- Updated timeline

Background

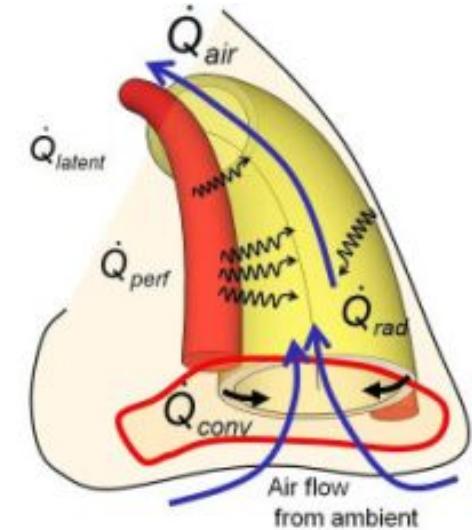
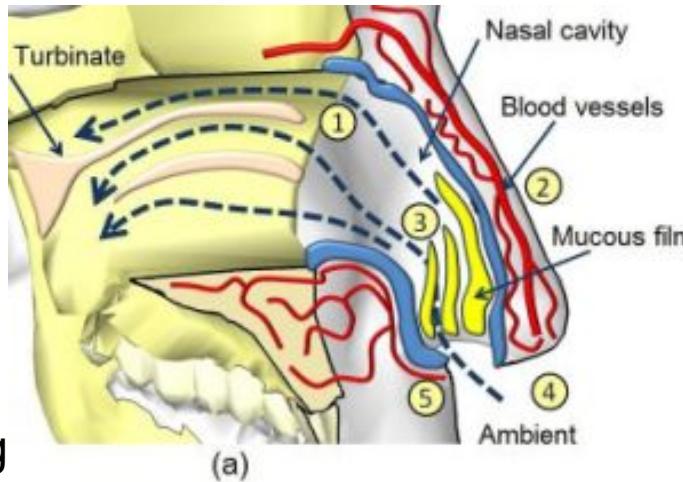
The geometry of elderly noses is different from those of young, healthy adults

These differences have been shown to have a detrimental impact on the quality of life of the elderly



Air Conditioning

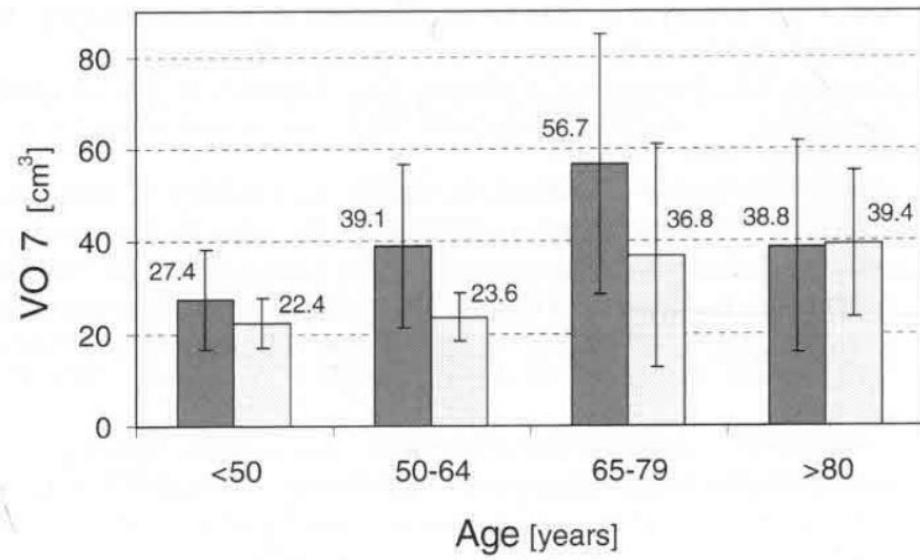
- One of the primary functions of the nasal cavity
- Conditions air for interaction with the lung
- Sensitive to geometry



Picture from Abbas, Abbas K et al. "Neonatal Non-Contact Respiratory Monitoring Based on Real-Time Infrared Thermography." BioMedical Engineering OnLine 10 (2011)

Geriatric Rhinology

- The nasal cavity deteriorates with age
- Complaints of dryness and itching, coldness
- Increased respiratory disease
- Reduced air conditioning
- Expanded geometries



Average endonasal volumes by age group, taken from Kalmovich, L. M. et. al. "Endonasal geometry changes in elderly people: acoustic rhinometry measurements" J Gerontology: medical sciences 3 (2005)

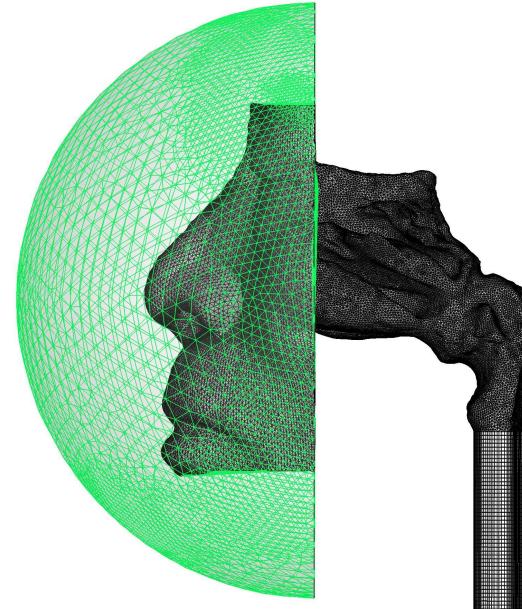
Experimental methods

- Rhinomanometry
- Acoustic rhinology
- Temperature and humidity probes
- 3D imaging
- Particle image velocimetry



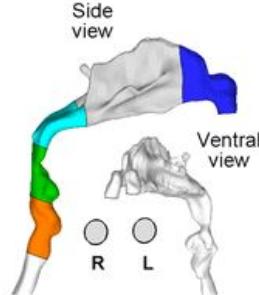
Computational Fluid Dynamics

- High detail
- Relatively cheap
- Compare different geometries

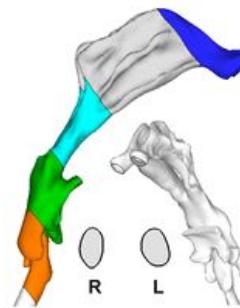


Demographic comparisons

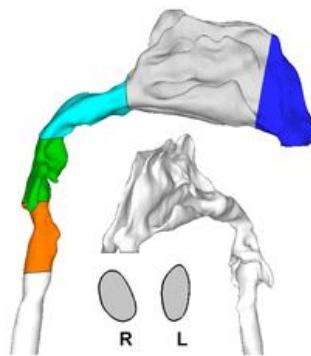
(a) 10-day-old girl



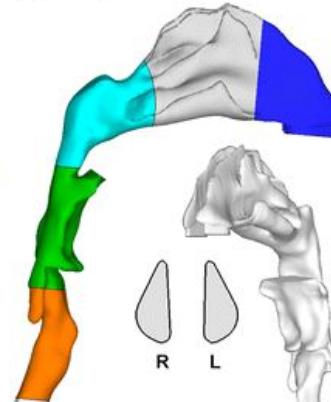
(b) 7-month-old girl



(c) 5-year-old boy



(d) 53-year-old male



- Compared demographics include ethnicity, sex, and age
- Age comparisons have shown marked variations in flow structure
- To date no one has examined elderly nasal cavities

Picture from Xi, J.; Berlinski, A., Zhou, Y., Greenberg, B. & Ou, X. "Breathing Resistance and Ultrafine Particle Deposition in Nasal-Laryngeal Airways of a Newborn, an Infant, a Child, and an Adult" Annals of Biomedical Engineering (2012)

Research questions

- what variations can be observed in the airflow structures between the nasal cavities of young adults and geriatric patients?
- How do any observed variations in flow structure impact upon the air conditioning capacity of the nasal cavity?

Objectives

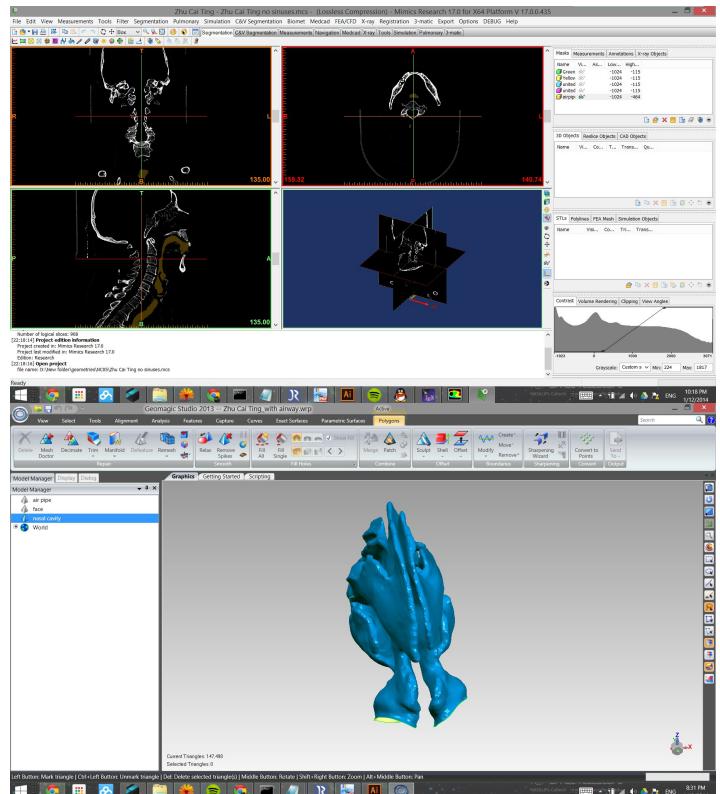
- Extract and compare elderly nasal cavity geometries ✓
- Analyse airflow ✓
- Analyse heat and vapour transfer
- Analyse particle deposition

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Geometry reconstruction

- Ct scans reconstructed from 78 year old patient
- Geometry refined using various software packages
- meshed with ICEM



Geometry comparison

- Compared output from elderly geometry with that of younger individual
- Discrepancy noted

Volume (cm ³)			Surface area (cm ²)			effective diameter (cm)		
Elderly	Young adult	%diff	Elderly	Young adult	%diff	Elderly	Young adult	%diff
32.33	25.48	26.87	204.25	198.82	2.73	0.63	0.51	19.03

Comparison of young and elderly models

Airflow analysis

- Governing equations solved with FLUENT
- resting and moderate flow rates
- Steady state
- Isothermal

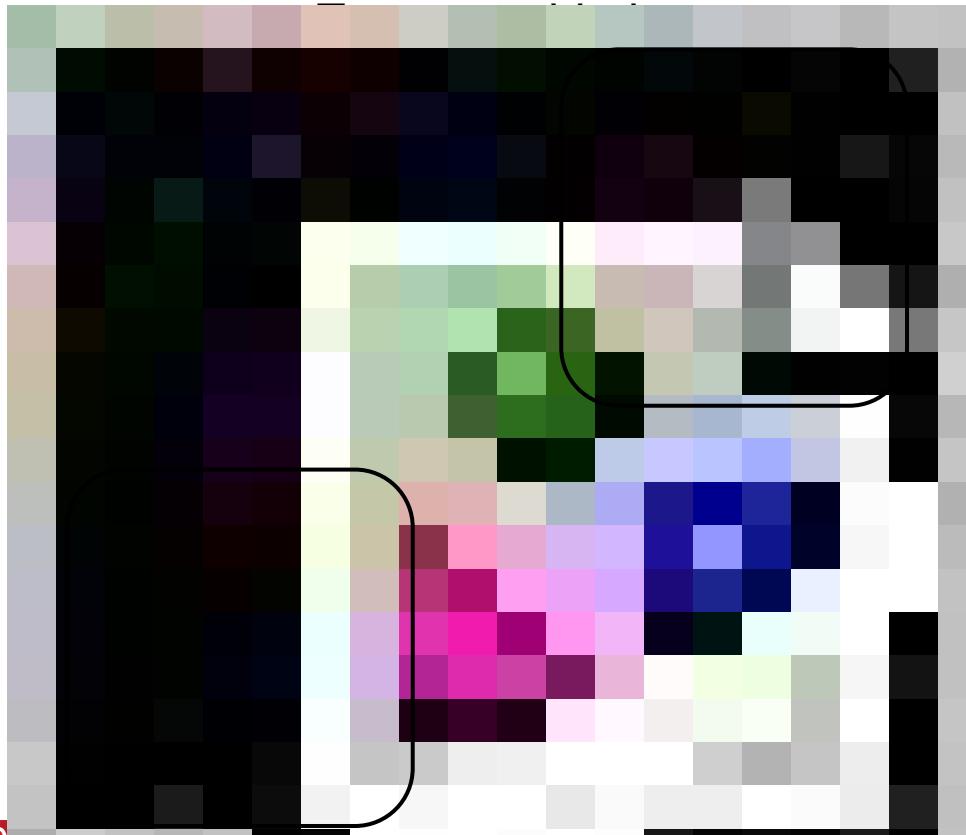
$$\frac{\partial}{\partial x_i} (\rho_g u_i^g) = 0$$

$$u_j^g \frac{\partial u_i^g}{\partial x_j} = -\frac{1}{\rho} \frac{\partial p_g}{\partial x_i} + \frac{\partial}{\partial x_j} \left(\nu_g \frac{\partial u_i^g}{\partial x_j} \right)$$

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Current research

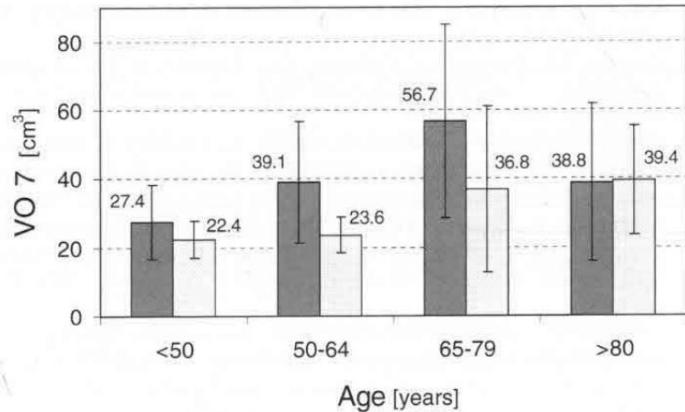


Geometry Comparison

Volumetric Comparison:

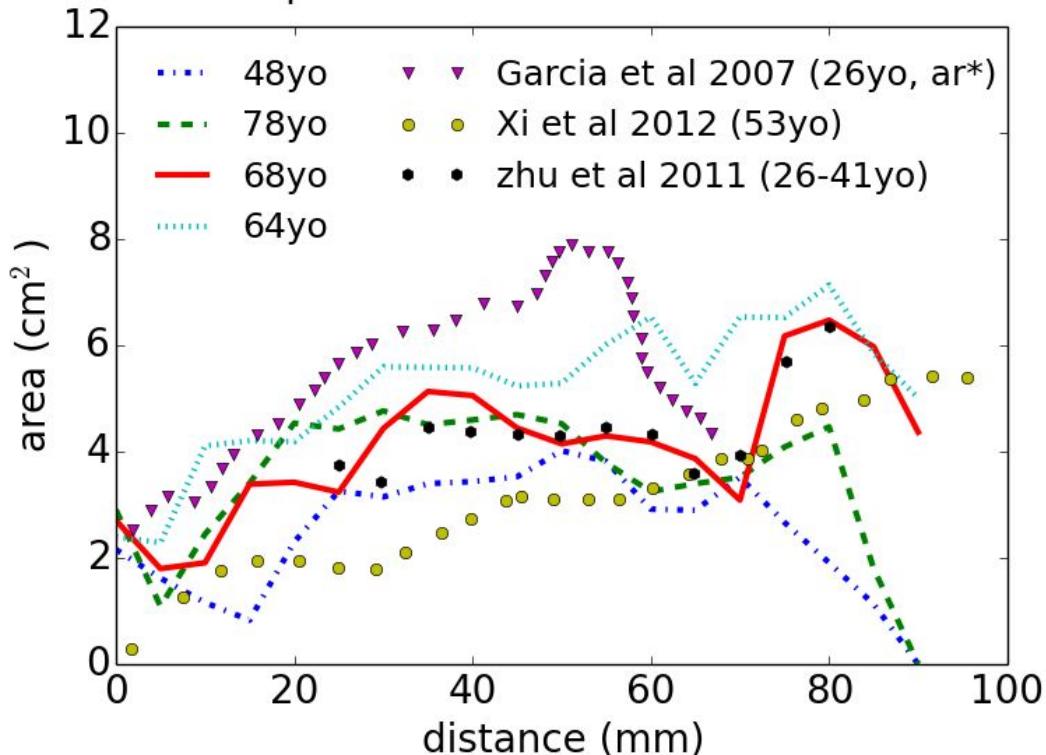
Remembering that

Model	Volume (cm ³)	Minimum cross section area (cm ²)
→ 48yo	25.48	0.83
→ 64yo	55.07	2.29
68yo	40.23	1.80
78yo	34.43	1.09

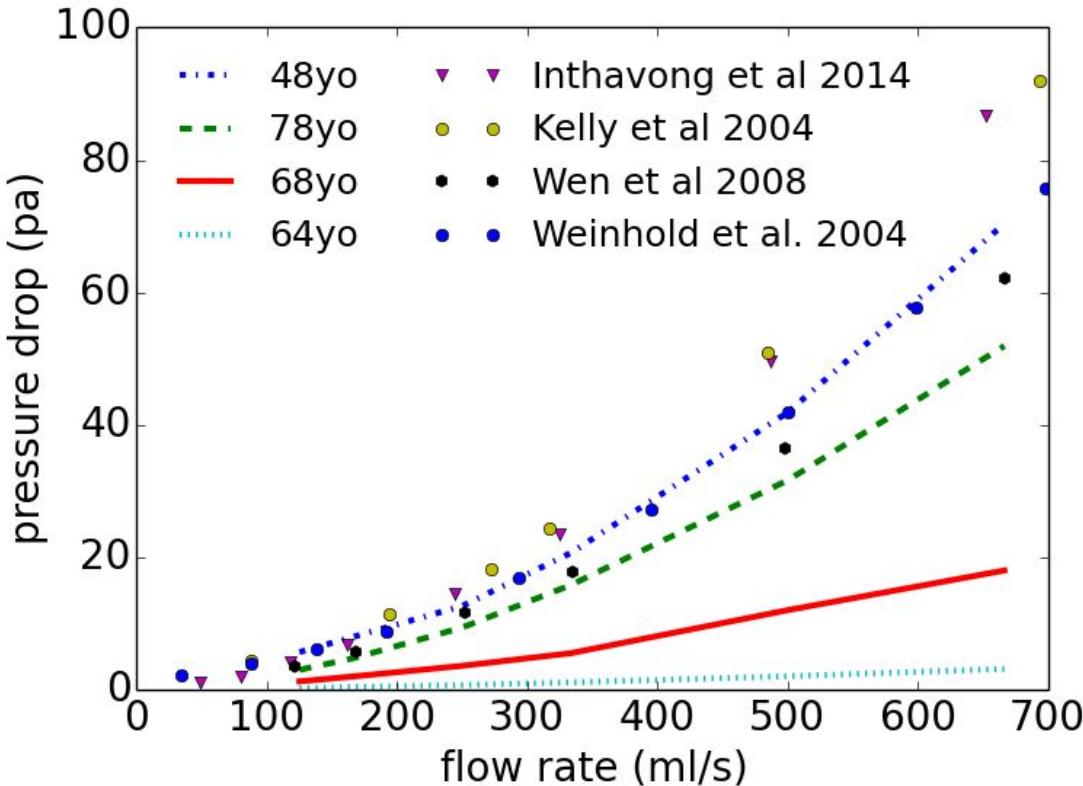


Geometry comparison

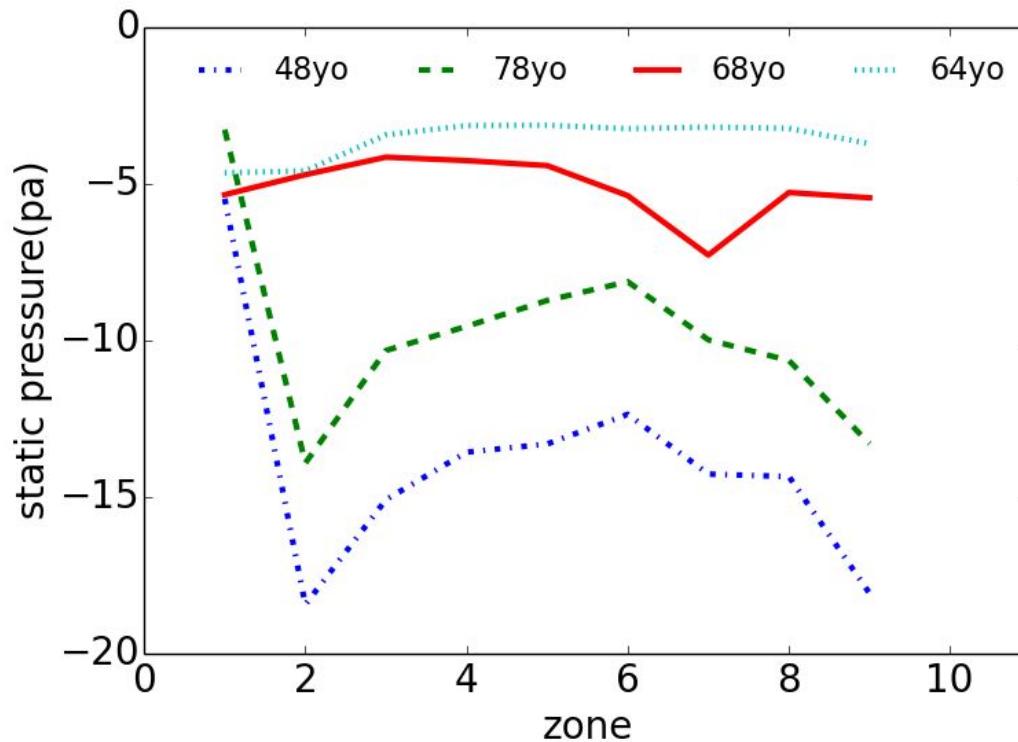
*ar=atrophic rhinitis



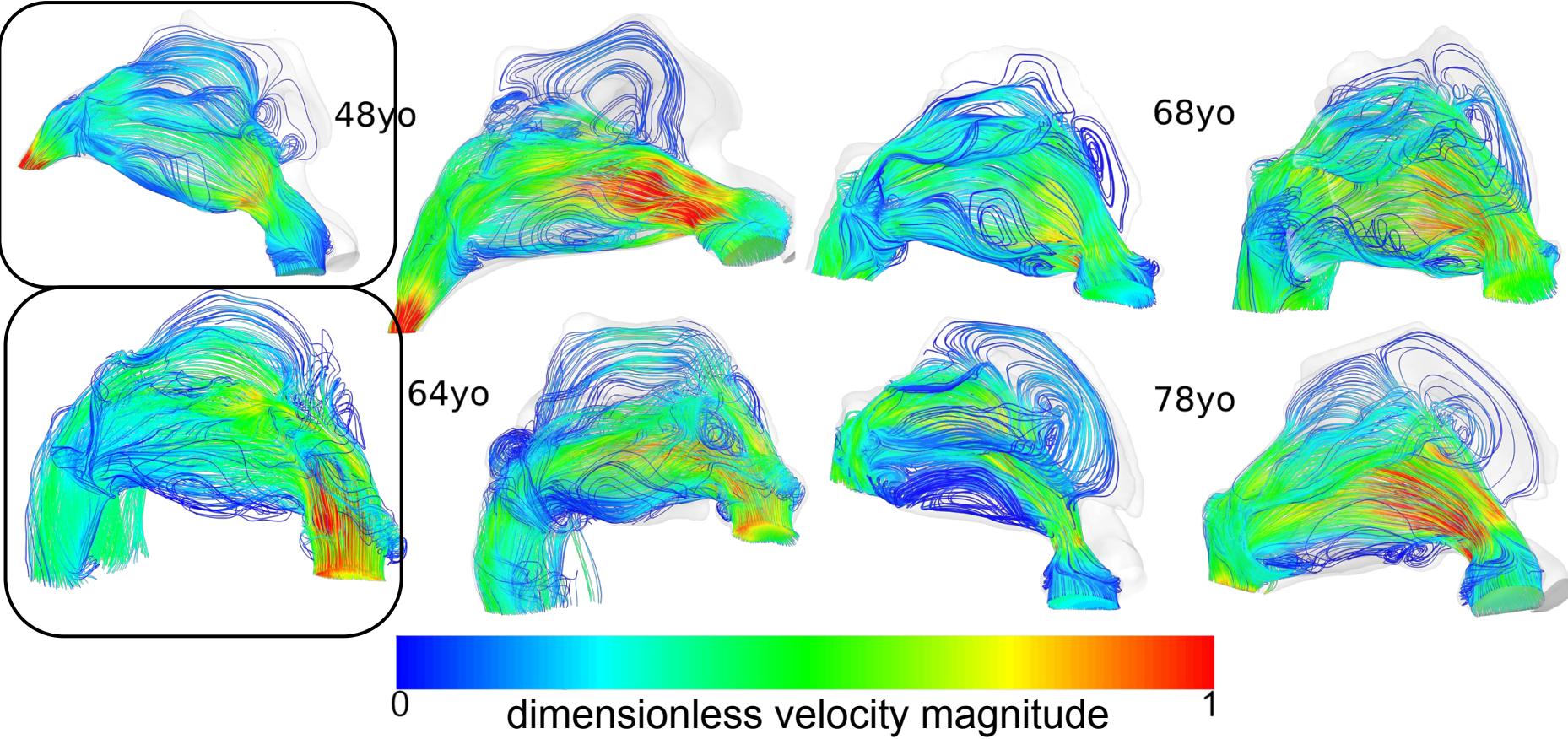
Validation



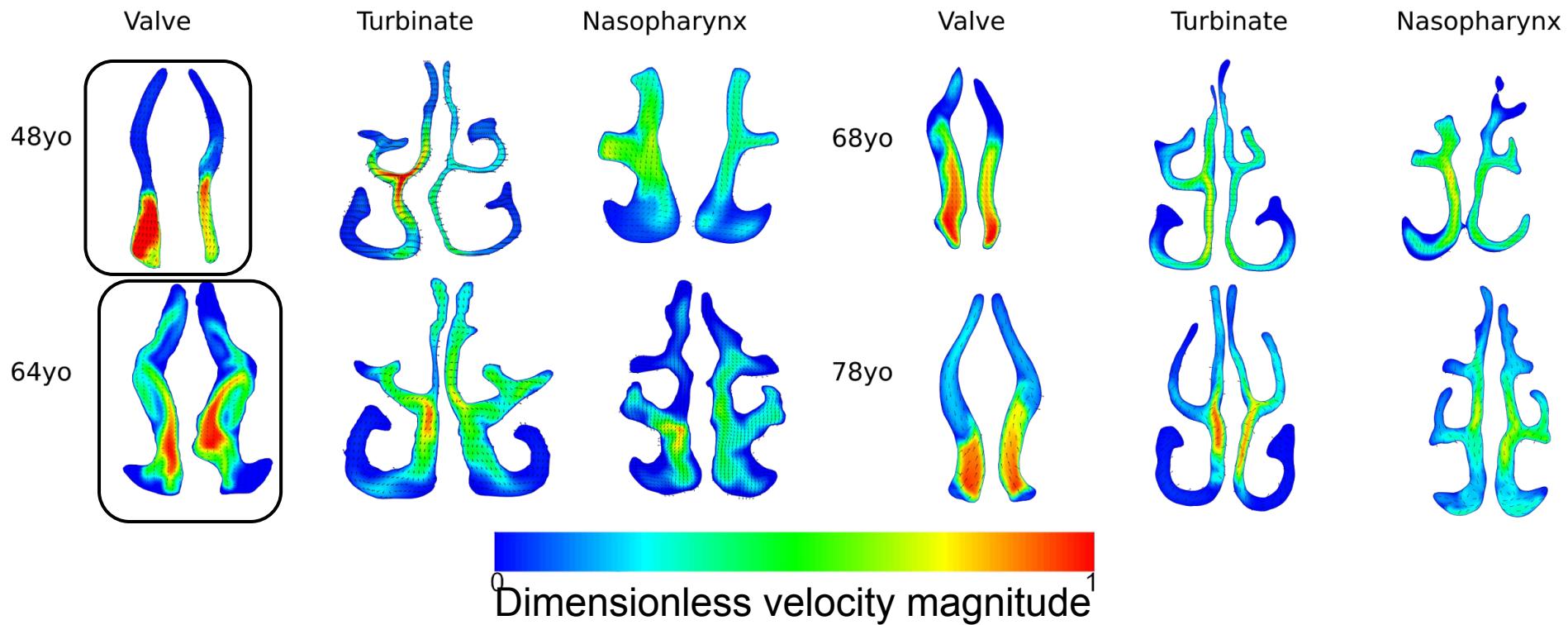
Static pressure vs zone (10l/min)



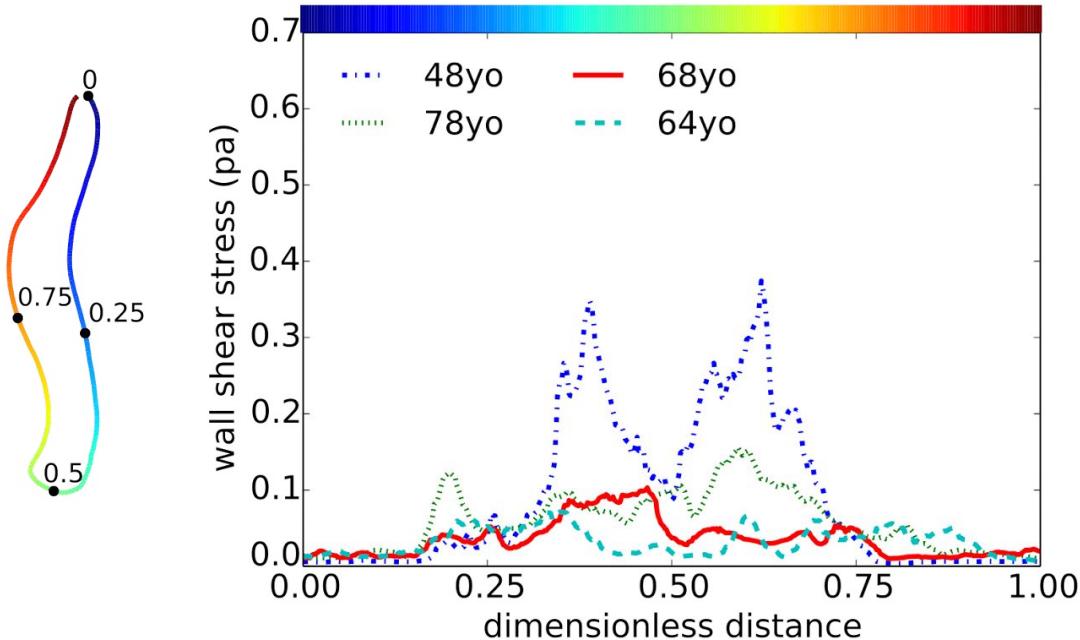
Streamlines



Anterior Cross sections



Wall shear stress



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Heat and mass transfer

- Solve for heat and mass transport (constant temp, 100% humidity at wall)
- Investigate across the domain
- compare between the models

Particle tracking

- Lagrangian tracking
- Deposition analysis
- comparison between models

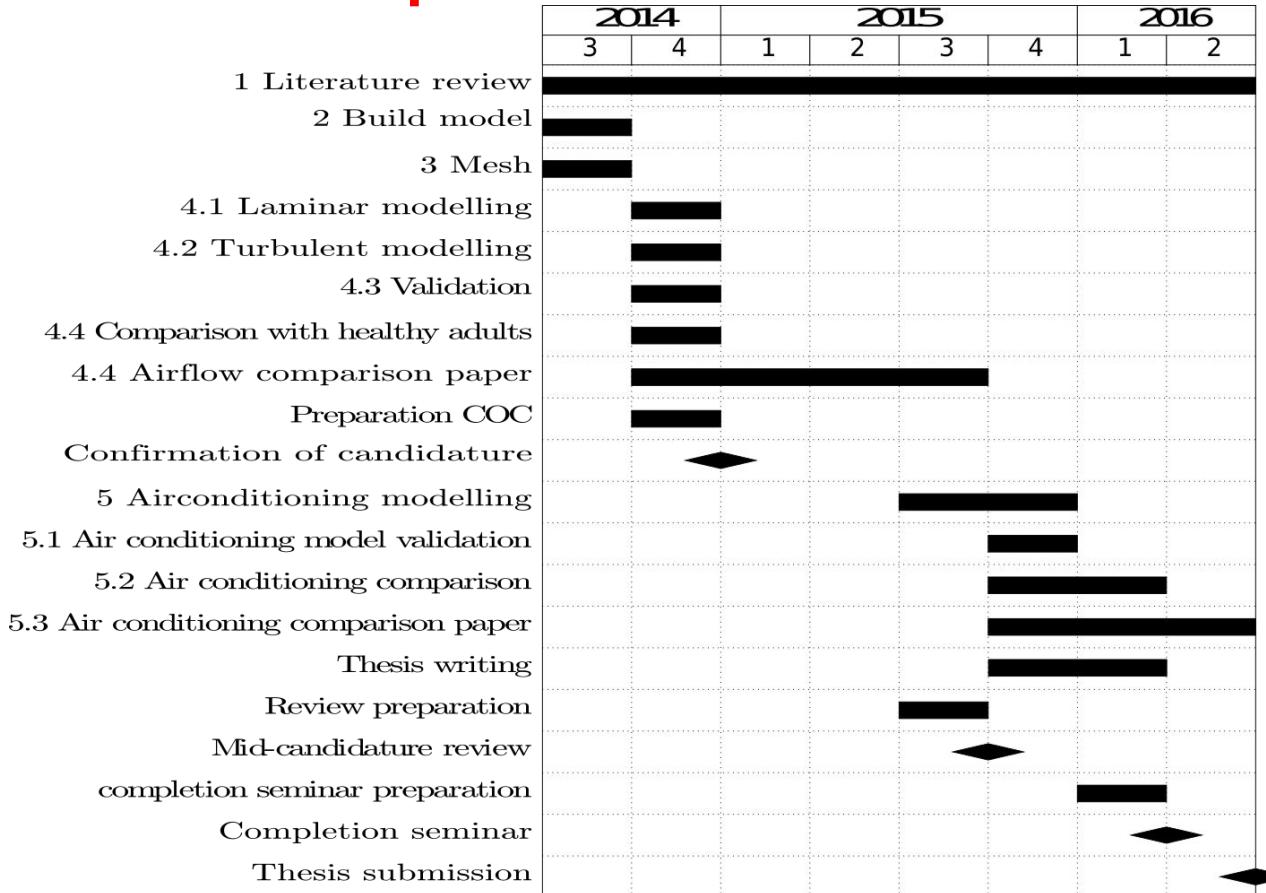
Planned publications

- Submission to Journal of Respiratory Physiology & Neurobiology (impact factor 1.971)
- Air conditioning paper

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Updated Gantt chart



Thank you for listening