

Physiological morphology of the right nasal cavity for three patient cases

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Abstract

The nasal airways accomplish a diverse range of functions: warming, humidifying and cleansing inspired air, and sampling for olfaction [Wolf, 2004]. Unsurprisingly, this brings about a complex the anatomical form of the nasal cavity. The Lagrangian dynamics of marker particles illustrate both the dynamics of the flow field and can be used to quantify the degree of convective mixing (or stirring) resulting from the complex morphology. Figure 1 illustrates a right nasal cavity surface geometry and the nomenclature of the distinct regions.

Results of 3 patient cases are given for constant inspiration at rest (100 ml/s), equivalent to quiet, restful breathing. The Newtonian, incompressible, Navier-Stokes equations were solved to third order accuracy using the Fluent CFD code.

Geometry deconstruction via Fourier descriptors [Gambaruto, 2008] is used to divide the nasal passage into regions and describe the flow features locally with aimed inter-patient comparison.

Measures obtained from the pathlines include, mixing based on the Shannon entropy [Kang, 2004] and mean transit paths. Vortical structures and recirculation zones are identified.

For the patient cases studied, results indicate: the mean washout time (time for a particle to transit from inflow to outflow) ranges from 0.13s to 0.20s; relatively little mixing occurs, $\tilde{30}\%$, with respect to the theoretical maximum by the time that the flow reaches the nasopharynx.

The portion of the flow that passes through the olfactory region originates from directly in front of the subject; quiet steady olfaction thus samples principally a specific region of the inspired volume, with relatively little mixing by the time the flow reaches the olfactory region ($\sim 10\%$).

Keywords: nasal cavity, morphology, geometry deconstruction, Lagrangian dynamics, entropic mixing.

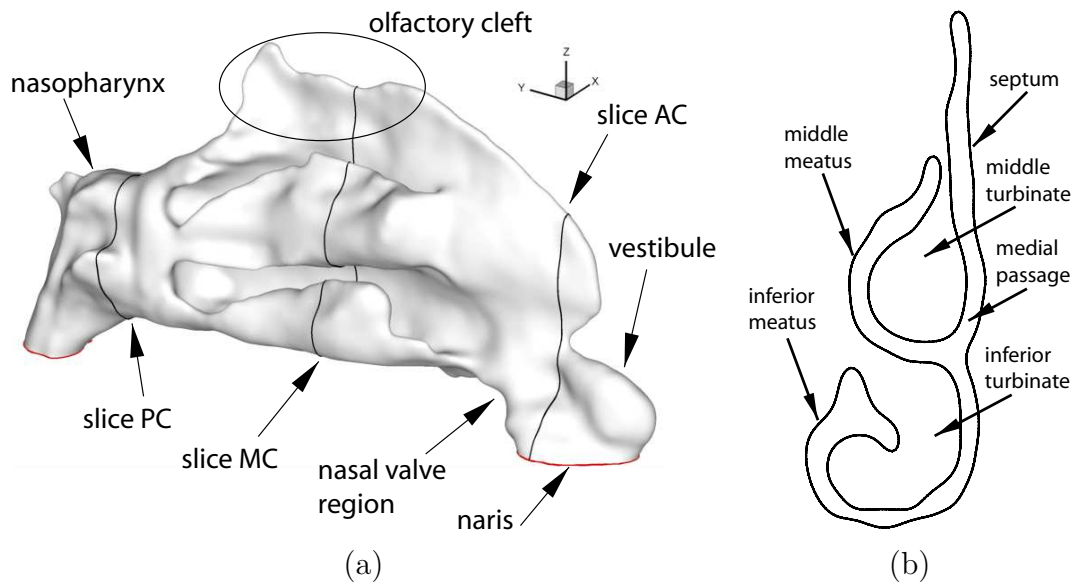


Figure 1: Nomenclature of right nasal cavity airway (patient case 3). The surface shown in (a) is the boundary of airway to surrounding solid structure. The location of illustrative slices taken in the anterior (AC), middle (MC) and posterior (PC) cavity regions are also shown. Slice MC is shown in (b) in the coronal plane.

References

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