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VIEWPOINT

The Myth of the Internal Nasal Valve

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According to ancient Greek myth, the Strait of Messina between Sicily and Calabria in southern Italy is home to Charybdis, a sea monster capable of bringing down the toughest ships by swallowing them whole. Of course, there was no monster and both ship and sailor fell victim to a whirlpool, an aquatic vortex resulting from a recirculating flow produced by the interaction of opposing currents. DaVinci described vortices within the human body, theorizing that the sinuses of Valsalva in the heart created vortices that prevented clot formation and facilitated aortic valve closure.[1]

Like Charybdis, there is a myth about the flow inside the nasal vault, and the historical description of the "internal nasal valve"[2] fails to be either accurate or descriptive in light of what is now dogma in the field of aerodynamics. The archaic description of an angular region bounded by the inferior turbinate, septum, nasal floor, and upper lateral cartilage (ULC), poorly describes both the 3-dimensional (3D) structure and the flow.[3] In fluid mechanics an inlet is a passage through which fluid first enters a machine or device.[4] Similarly, gateways, described as archways built around a gate, are more apt descriptions for what the medical literature refers to as "valves"—terminology that is otherwise confusing to patients and nonsense to engineers. The fluid dynamics of the nose cannot be summarized with a single angular measurement. The anatomy is complex, with lateral attachments, overlying dilator musculature, and rigid nasal cavity structures contributing to the dynamic sidewall collapse as flow at high velocities generate considerable pressure differentials. Although imaging and computational fluid dynamics have accelerated our understanding immensely,[5] there still exists a lack of means to reliably predict lateral wall collapse.[6]

The Myth of a Valve

The very first descriptions of this anatomic region are that of a valvular structure, with defined boundaries, but no distinct beginning or end. A physiologic valve is an organ that stops or regulates flow, generally in 1 direction, by opening and closing. This implies that there are intrinsic aspects that regulate flow, either voluntarily or involuntarily. While there is a Starling effect with collapse that occurs as a pressure drop is achieved, this process is entirely passive. Engineers have grasped the truth behind the myth that has remained in our field—that a distinct process known as flow reversal, or vortical flow, is generated distal to the area of highest air velocity known as the valve (**Figure**).[5] Does this vortex during inspiration lead to increased airway resistance in this region? There truly is no valve, which raises the question of why we use this terminology at all.

What are the boundaries of this gateway? We have somehow asserted that the valve begins at 1.3 cm from the nares, though this locus has been debated and as well as refuted in clinical and computational modeling studies.[7] Our accepted boundaries do not consider the pyriform aperture to which the gateway extends, and direct examination, endoscopy, and imaging fail to identify any key demarcation between mucosal, cartilaginous and bony areas in 3D.[2]

The Myth of an Angle

The pervasive concept regarding a critical 10° to 15° angle between the caudal border of the ULC and septum,[2] which is more aptly suited to hearsay given the uncertainty of the region, is used both to obtain a diagnosis and plan surgical therapy.[2,8] The importance of this angle as the fundamental feature of the internal nasal valve is perpetuated in the literature and remains a key concept for physician trainees. In reality, this gateway exists in 3D with a complex geometry,[8] and accurate measurement using physical examination, endoscopy, and imaging is inconsistent at best. Considering this angle in isolation as a means to guide treatment is, therefore, inappropriate. If we treat this angle in rhinoplasty, should this not result in predictable resolution of dynamic obstruction? Spreader grafts are now widely used to correct valve collapse; however, their long-term results may be inconsistent, perhaps because the nature of collapse is incorrectly diagnosed.[2] Flaring sutures and butterfly grafts, among other approaches for treating valve collapse, work by using an entirely different principle. This concept of the single critical angle is unsubstantiated, is impossible to reliably measure, and ignores the complex anatomic structures contributing to collapse.[2]

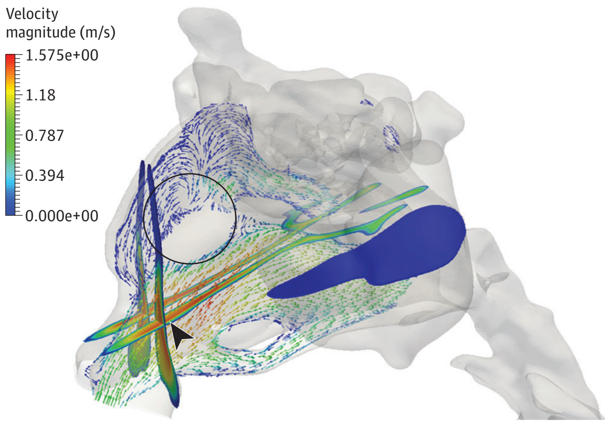
The Myth of Nasal Airflow

Vortices are fully explained by laws of fluid mechanics,[5] though formal description and analysis requires advanced computational methods only recently applied to nasal air flow. For most of the past century, nasal air flow has been described with principles of Bernoulli,[2] but these fail profoundly because they do not take into account wall stress, assume uniform geometry, and are incompatible with vortical flow. The nasal airway shape is complex and is anything but tubelike.[8] Applying these limited approximations ignores a fundamental concept: distal vortical flow or local flow reversal.[4] This vortex-type flow is generated by rapid expansion distal to the gateway's narrow area.

Conclusions

Nasal gateway is a better and more descriptive term for the flow limiting region of the nose, and the nomenclature

Figure. Air Velocity Vectors in the Sagittal Plane of the Nasal Airway



The velocity reaches a maximum within the internal nasal valve (arrowhead). A vortex flow is seen distal to this (black circle) secondary to rapid expansion. Velocity magnitude of each vector is scaled by color. m/s Indicates meters per second.

we propose to replace the terminology of *valve*. There is no airflow regulation by any intrinsic mechanism and hence no valve. The shape is variable, and therefore, the very idea of an angle is misleading. The use of the descriptor *inlet* is well-defined in the fluid mechanics literature, describing the first site of airway, or the external valve. Therefore, *gateway* is more accurate in its description of the internal nasal valve. This area begins approximately 2 cm from the nares according to 3D modeling,[7] and potentially extends at least 1 cm beyond the pyriform given its lateral relationships. When narrowing or expansion occurs, vortical flow is generated.

Science replaces myth as knowledge replaces ignorance; our rudimentary view of the internal nasal valve has been poorly understood by our specialty, and we need to learn from colleagues in mechanical and aerospace engineering. The misunderstanding of flow mechanisms through the nasal gateway leads to limitations in reliable diagnosis and treatment. Changing the name to a more accurate descriptor is the first step in moving toward a more logical understanding of this complex organ's physiology.

ARTICLE INFORMATION

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