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Research Abstracts

Impact of Sinus Surgery on Nitric Oxide Concentration in the Maxillary Sinus

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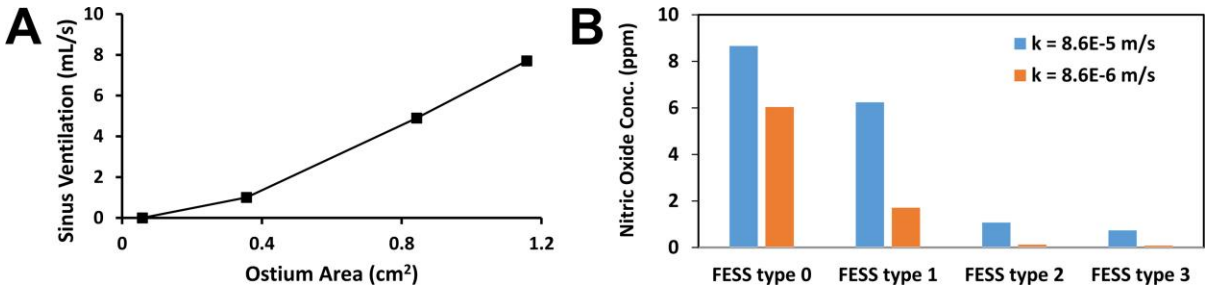
Introduction: Chronic rhinosinusitis (CRS) affects up to 12% of adults and is frequently treated with functional endoscopic sinus surgery (FESS). Despite its widespread use, FESS has a 20-30% failure rate, with persistent infection often attributed to biofilms and impaired mucociliary clearance. The "nitric oxide (NO) hypothesis" proposes that enlargement of the sinus ostium during FESS reduces NO concentration inside the paranasal sinuses, thereby compromising host defense. NO is produced abundantly by sinus epithelia, has bactericidal effects, and enhances mucociliary clearance. However, the quantitative relationship between ostium diameter and sinus NO concentration remains poorly understood.

Methods: A three-dimensional model of the nasal cavity and paranasal sinuses was constructed from a computed tomography (CT) scan of a healthy subject and modified via virtual surgery to create four variations representing progressively larger maxillary ostium diameters, simulating FESS outcomes. Computational fluid dynamics (CFD) simulations of NO release and transport were performed in ANSYS Fluent for a steady-state inhalation rate of 15 L/min. Two values of the NO production rate were estimated from the literature.

Results: Simulations showed that sinus ventilation increased (Figure 1A), while maxillary sinus NO concentration decreased sharply with ostium enlargement (Figure 1B). At small ostium areas (FESS type 0-1), NO levels remained within the physiological range (6-9 ppm). However, when the ostium size exceeded ~0.8 cm^2 (FESS type 2-3), NO concentration dropped below 1 ppm for both values of NO production rate.

Conclusions: These findings support the nitric oxide hypothesis, demonstrating that enlargement of the maxillary ostium increases sinus ventilation and decreases sinus NO concentration. The loss of the bactericidal properties of NO and its role in regulating mucociliary clearance likely contribute to persistent sinus infections after FESS. Further research incorporating multiple patient anatomies and experimental validation is needed to further test this hypothesis.


A
Sinus Ventilation (mL/s)
10
8
6
4
2
0
0
0.4
0.8
1.2
Ostium Area (cm²)
B
Nitric Oxide Conc. (ppm)
10
8
6
4
2
0
k = 8.6E-5 m/s
k = 8.6E-6 m/s
FESS type 0
FESS type 1
FESS type 2
FESS type 3