

# Paranasal Sinus Accessibility of Large Volume Saline by Intranasal Instillation in Various Head Positions

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**Objective:** To determine the distribution of instilled fluid to various sinonasal areas for a large volume intranasal instillation at various head positions in fresh frozen cadavers.

**Material and Method:** This experimental study was conducted by intranasal instillation of a large volume saline mixed with contrast media in four fresh frozen cadavers at three different head positions (Mygind, vertex-to-floor and Ragan positions) before and after functional endoscopic sinus surgery (FESS). The presence of saline in nasal cavities and paranasal sinuses were determined by Cone beam computed tomography of paranasal sinuses and assessed by a radiologist and a rhinologist.

**Results:** Vertex-to-floor and Mygind head positions could deliver a large volume saline to the olfactory cleft, the sphenoethmoidal recess and the frontal recess either before or after FESS. After FESS, vertex-to-floor position could deliver more saline into the anterior ethmoid sinus and the frontal sinus than other sinuses, while Mygind head position delivered more saline into the sphenoid sinus, posterior ethmoid sinus and anterior ethmoid sinus than the maxillary and the frontal sinuses. Ragan position delivered a large volume saline to the olfactory cleft and the sphenoethmoidal recess more than the frontal recess either before or after FESS. After FESS, Ragan position delivered more saline into the maxillary sinus than other head positions.

**Conclusions:** This is the first study to determine the deposition of a large volume saline after nasal instillation at sinonasal locations. It demonstrated that various head positions have different effects on the deposition of saline administration. This result may be applied to patients by delivery of topical medication to specific sinonasal areas to increase medication-mucosal contact time as long as the head remains in the proper position.

**Keywords:** Ragan position, Mygind position, Vertex-to-floor position, Intranasal instillation, Head position

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Chronic rhinosinusitis is a common inflammatory condition of nasal sinuses. The mainstay medical treatment consists of nasal irrigation and corticosteroids as a short-term systemic steroid, nasal spray, nasal nebulizer, nasal drop or irrigation by mixing in normal saline. However, failure with medication and quality of life disturbance may need functional endoscopic sinus surgery (FESS) which aims to establish the ventilation and drainage of the sinuses, to remove diseased tissues and to establish unobstructed tract for topical medication access. There was a study showing 90% favorable outcomes of FESS for chronic rhinosinusitis<sup>(1)</sup>. However, 15 to 20% of the

operative patients needed revision surgery<sup>(2-4)</sup>. One reason for failure of FESS is the uncontrollable inflammation of the sinonasal areas.

Currently, topical steroid is commonly used to control the sinonasal inflammation that occurs after FESS<sup>(5,6)</sup> and that could be delivered to sinonasal areas as nasal nebulizer, nasal irrigation using squeeze bottle, or nasal drops. However, nebulizers deliver topical medication to paranasal sinus less than using squeeze bottle in post FESS<sup>(7)</sup>. The studies on nasal drops with various head positions were conducted mostly in non-operated patients and assessed the depositions only in the intranasal areas. Moreover, these studies used only 1 to 3 drops of solution into each nasal cavity which might not be delivered to cover the mucosa of paranasal sinuses<sup>(8-16)</sup>. Currently, nasal irrigation with squeeze bottle is the most popular method to deliver saline or topical medications into the paranasal sinuses after FESS. However, it showed that less than 5% of

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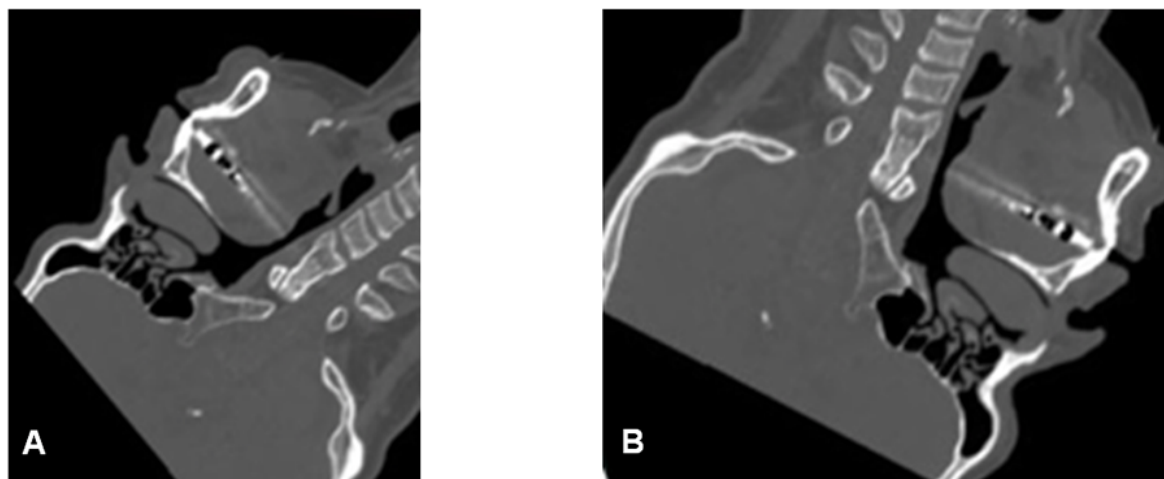
the irrigated medication remained within the sinonasal area<sup>(6)</sup>.

Mygind or lying head back position, vertex-to-floor position and Ragan (lateral head-low) position are of great interest to deliver medication to the sinonasal areas and to maintain the medication-mucosal contact time<sup>(8-15)</sup>. When looking at the position of the paranasal sinuses during Mygind position, the sphenoid sinus is at the lowest position, followed by the posterior ethmoid sinus, the anterior ethmoid and frontal sinuses. For the vertex-to-floor position, the frontal sinus is at the most dependent part, followed by the anterior ethmoid, the posterior ethmoid and the sphenoid sinuses (Fig. 1). However, the maxillary sinus is at the most dependent part for the Ragan position. Therefore, if we instill a large volume saline intranasally, the fluid is expected to flow to the dependent part and stay there as long as the head is fixed in that particular position. The aim of this present study was to determine the distribution of saline to various intranasal and paranasal sinus locations at the three head positions after nasal instillation before and after FESS.

#### Material and Method

This experimental study was conducted at the ENT surgical skill laboratory room, Department of Otorhinolaryngology, Faculty of Medicine, Khon Kaen University, Thailand during December 2014 and January 2015. Four fresh frozen cadavers whose age at death were at least 18 years, had normal sinonasal cavities,

and had no deviated nasal septum, nasal tumors, history of previous sinonasal surgery or trauma, were selected. Before nasal instillation at each head position, the nasal cavities were cleaned and CT scans of the paranasal sinuses were performed using Cone Beam CT: CereTom Neurologica 05.08<sup>®</sup> with the exposure of 120 KVp, 6 mA, 1,000 msec to assure that the paranasal sinuses and nasal cavities were intact and there was no fluid retain in sinonasal areas. Normal saline mixed with omnipaque (5: 1) and fluoresceine dye 0.1 ml per 100 ml saline were used for intranasal instillation. During the intranasal instillation for Mygind and Ragan positions, a telescope was inserted through the oral cavity to inspect the saline in the oropharynx and stopped the instillation when the yellow fluid was seen in the oropharynx. For the vertex-to-floor position, intranasal instillation was stopped as soon as the excess fluid dripped from the nostrils. Nasal instillations were performed simultaneously through both nasal cavities for Mygind and vertex-to-flow positions. However, it could be done only through each nasal cavity at a time for Ragan position. A 20-ml syringe was used to instill saline with the tip of the syringe was just below the lower lateral cartilage and saline was instilled slowly so that it flowed along the walls of nasal cavities. CT PNSs were performed before and after intranasal instillation. After completion of the study, for the non-surgical cadavers, FESS was performed by widening the natural outflow tracts of all paranasal sinuses as wide as possible. Then the study was repeated as mentioned



**Fig. 1** The most dependent part of paranasal sinuses. A) Mygind position showing the sphenoid sinus is at the lowest position, followed by the posterior ethmoid, the anterior ethmoid and the frontal sinuses. B) Vertex-to-floor position showing the frontal sinus is at the lowest position, followed by the anterior ethmoid, the posterior ethmoid and the sphenoid sinuses.

previously. All cadavers were cleaned with saline irrigations and endoscopically fluid removed with suction before commencing intranasal instillation for other positions. The distribution of the fluid to the sinonasal locations was assessed independently by one radiologist (WP) and one rhinologist (ST). Consensus agreement was done in case of disagreement. However, if consensus agreement could not be reached, the final assessment was done by another rhinologist (PK). The intranasal locations to be assessed were the frontal recess, the olfactory cleft and the sphenoethmoidal recess which were assessed as presence or non presence of the contrast media seen. The distributions to the paranasal sinuses were assessed as absence/rare presence, presence less than 50% and presence at least 50% of the sinus cavities. Nominal data were presented. This study was exempted for human research approval by The Khon Kaen University Ethics Committee in human research (HE 571467) since it was conducted on cadavers.

## Results

This present study demonstrated that the various head positions had the effects on delivery of fluid into the paranasal sinuses as followings.

### *Fluid distribution in pre-FESS head positions (Table 1, Fig. 2-4)*

The vertex-to-floor and Mygind head positions could deliver fluid to the olfactory cleft, the frontal recess and the sphenoethmoidal recess in 8/8

vs. 8/8, 6/8 vs. 6/8 and 6/8 vs. 8/8 sides, respectively, while the Ragan head position could deliver to the frontal recess less than the vertex-to-floor and Mygind positions. Regarding the distribution to the paranasal sinuses, the result showed that it rarely delivered fluid to the sinuses in non-operated condition. However, a few cadavers showed fluid in some paranasal sinuses at least 50% of the sinus volume, for example the vertex-to-floor position could deliver fluid into the frontal sinus, the anterior and posterior ethmoid sinuses in only 2/8, 2/8 and 1/8, respectively.

### *Fluid distribution in post-FESS head positions (Table 2, Fig. 2-4)*

The vertex-to-floor head position could deliver fluid to both sides of the olfactory cleft, the frontal recess and the sphenoethmoidal recess (8/8), while Mygind position could deliver to the olfactory cleft (8/8) and the sphenoethmoidal recess (8/8) more than into the frontal recess (6/8). Ragan head position could deliver fluid to the olfactory cleft (8/8) more than the sphenoethmoidal recess (6/8), and the frontal recess (3/8), respectively. Regarding paranasal sinus depositions, it demonstrated that the fluid was found in the frontal sinuses and the anterior ethmoid sinuses at the vertex-to-floor position more than the Mygind and Ragan positions, while sphenoid sinus distribution was found more in the Mygind and the Ragan positions (7/8 & 7/8) than the vertex-to-floor position (1/8). Interestingly, the maxillary sinus was found to have fluid in only the Ragan position (6/8) more than the

**Table 1.** Number of various sinonasal locations for fluid depositions in various head positions after FESS

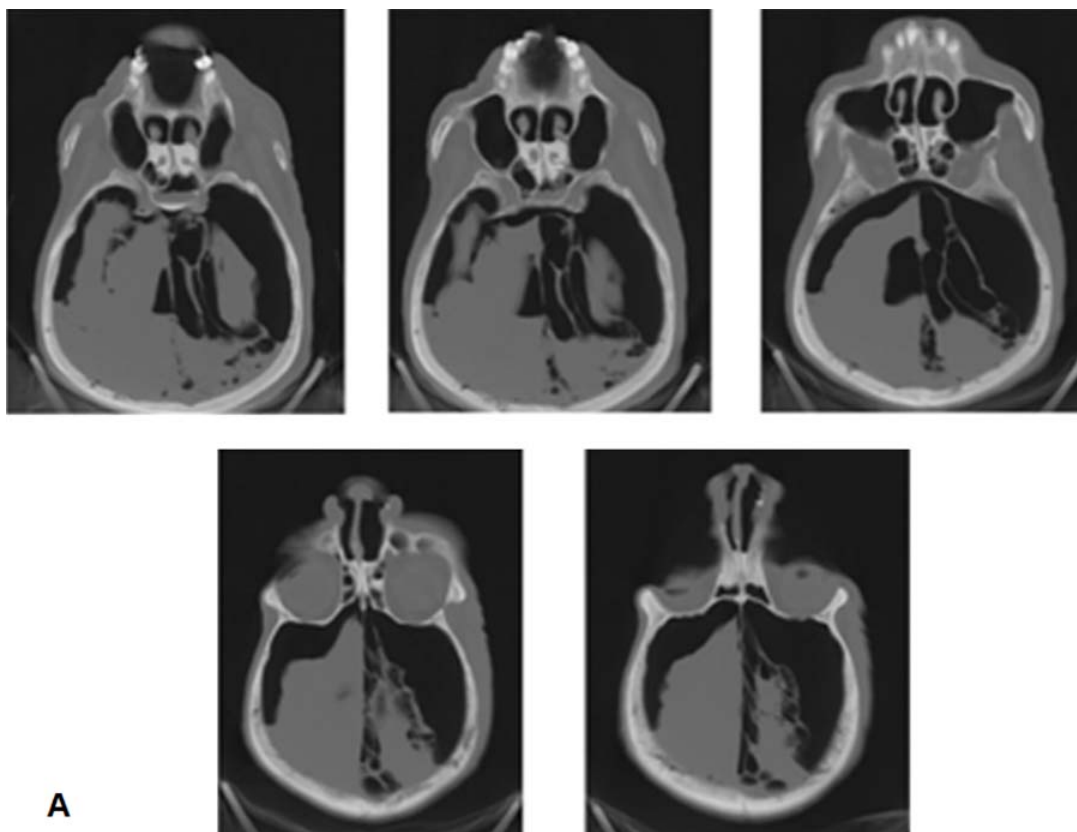
Locations	Head Positions, Before FESS								
	Vertex-to-floor			Mygind			Ragan		
	A	B	C	A	B	C	A	B	C
Intranasal locations									
Frontal recess	2	6	NA	2	6	NA	5	3	NA
Sphenoethmoidal recess	2	6		0	8		0	8	
Olfactory cleft	0	8		0	8		0	8	
Paranasal sinuses									
Maxillary sinus	7	1	0	8	0	0	7	0	1
Anterior ethmoid sinus	0	6	2	2	6	0	2	6	0
Posterior ethmoid sinus	2	5	1	5	2	1	5	3	0
Sphenoid sinus	5	3	0	6	1	1	5	1	2
Frontal sinus	6	0	2	6	1	1	5	3	0

Paranasal sinuses: A = absent, B = present <50%, C = present at least 50%; Intranasal locations: A= absent, B = present

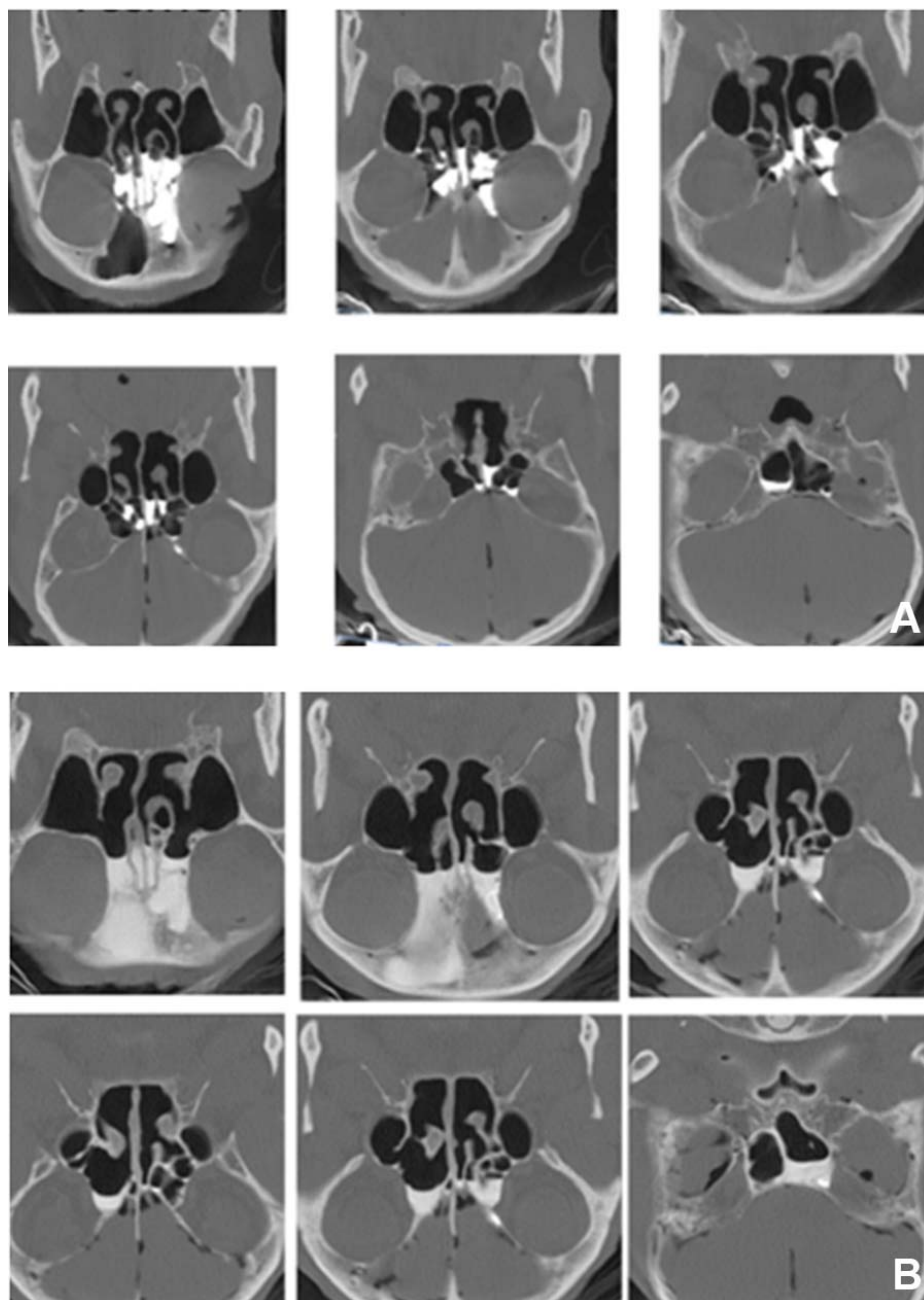
**Table 2.** Number of various sinonasal locations for fluid depositions in various head positions post-FESS

Locations	Head Positions, Post-FESS								
	Vertex-to-floor			Mygind			Ragan		
	A	B	C	A	B	C	A	B	C
Intranasal locations									
Frontal recess	0	8	NA	2	6	NA	5	3	NA
Sphenoethmoidal recess	0	8		0	8		2	6	
Olfactory cleft	0	8		0	8		0	8	
Paranasal sinuses									
Maxillary sinus	5	3	0	5	3	0	1	1	6
Anterior ethmoid sinus	0	0	8	0	2	6	2	3	3
Posterior ethmoid sinus	0	4	4	0	1	7	1	1	6
Sphenoid sinus	2	5	1	1	0	7	1	0	7
Frontal sinus	0	1	7	2	2	4	4	2	2

Paranasal sinuses: A = absent, B = present <50%, C = present at least 50%; Intranasal locations: A= absent, B = present



**Fig. 2** CT PNS in Mygind position. A) Before FESS showing contrast materials in the sphenoid & anterior ethmoid sinuses (less than 50%), sphenoethmoidal recess and olfactory cleft. B) After FESS showing contrast media in the sphenoid sinuses, posterior & anterior ethmoid sinuses, including olfactory cleft, sphenoethmoidal recess.



**Fig. 3** CT PNS in vertex-to-floor position. A) Before FESS showing contrast materials in the sphenoid & posterior sinuses (less than 50%), anterior ethmoid sinuses & left frontal sinus (at least 50%), sphenoethmoidal recess, olfactory cleft and frontal recess. B) After FESS showing contrast media in the frontal sinus, anterior & posterior ethmoid sinuses, including left sphenoid sinus, frontal recess, olfactory cleft, sphenoethmoidal recess.

other two positions (0/8).

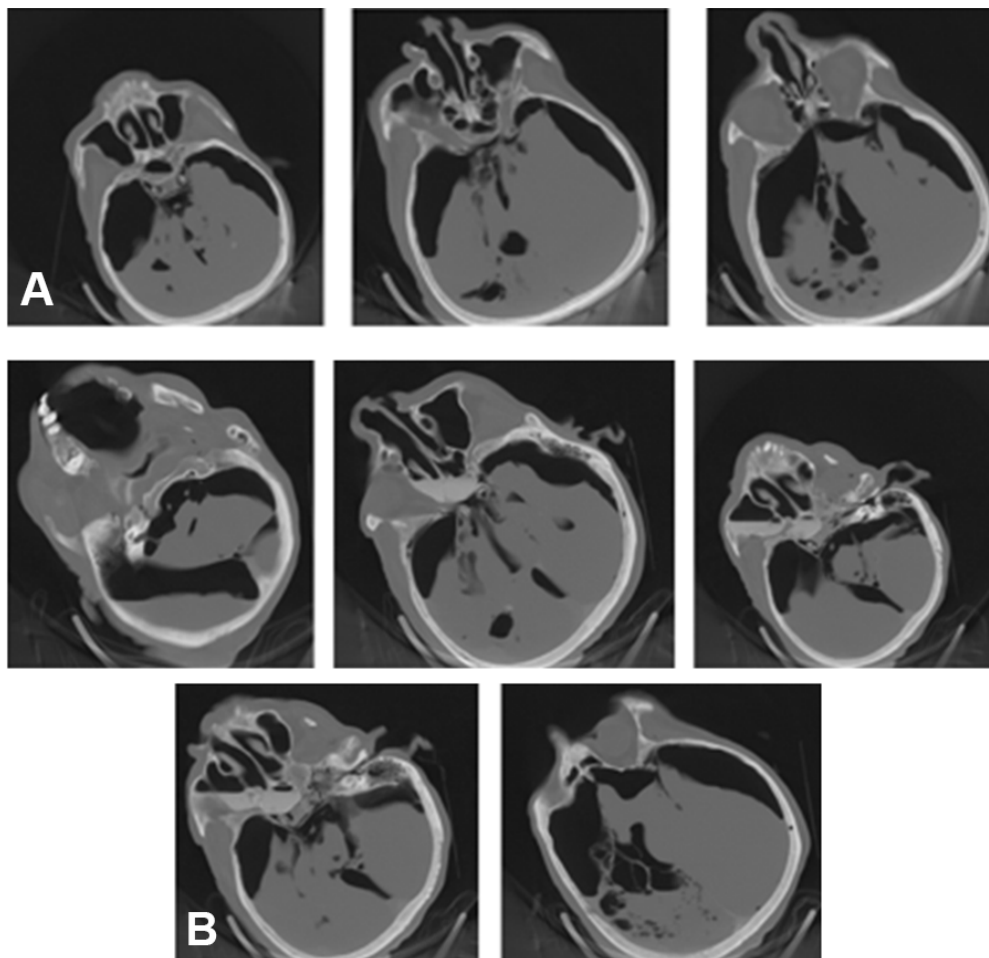
#### Discussion

This is the first study on intranasal instillation of a large volume saline in fresh frozen cadavers showing

that the various head positions have the effects for the delivery of fluid to various sinonasal areas.

Before FESS, it was found that the instilled fluid was rarely distributed to the paranasal sinuses for more than 50% of their volumes. Although a few





**Fig. 4** CT PNS in Ragan position. A) Before FESS showing contrast media in sphenothmoidal recess, and olfactory cleft. B) After FESS showing contrast media in the right maxillary sinus, sphenoid sinus and posterior ethmoid sinuses, including sphenothmoidal recess and olfactory cleft.

paranasal sinuses had fluid inside, this may not be extrapolated for human beings because the cadavers had some degree of shrinkage of nasal mucosa and the outflow tracts of the paranasal sinuses which would make the outflow tracts wider than usual. Roh et al<sup>(12)</sup> studied in normal volunteers by using 3-drop nasal instillation into each nasal cavity and showed that in the vertex-to-floor position the fluid distributed only to the olfactory cleft; and in the Mygind and Ragan positions, the fluid was found in the middle meatus which was contrary to our present study on fresh, frozen cadavers. Our present study demonstrated that instilled fluid could be distributed to the olfactory clefts in all of the three positions. Moreover, it could be distributed also to the sphenothmoidal and the frontal recesses. There had been other previous studies on nasal instillation in normal volunteers; however, they

used a few nasal drops<sup>(10-12,14,16)</sup>. Our present study used a large volume fluid instillation that could distribute the fluid to cover larger areas of sinonasal mucosa than using a few nasal drops.

Regarding post-FESS condition, our present study show that the instilled fluid could be distributed to the paranasal sinuses more than pre-FESS. The vertex-to-floor position could distribute the fluid to the frontal sinus, the anterior ethmoid sinus and the frontal recess more than the other two head positions, while the Mygind and the Ragan positions distributed fluid to the posterior paranasal sinuses (sphenoid and posterior ethmoid sinuses) more than the vertex-to-floor position. Regarding the distribution into the maxillary sinus, the Ragan position could deliver fluid to the maxillary sinus more than the other two positions. Roh et al<sup>(11)</sup> showed that in post-ESS patients, the

Mygind and the Ragan positions could deliver fluid to the maxillary sinus which was different from our present study. The present study showed that only the Ragan position could deliver the fluid to the maxillary sinus more than 50% of its volume. In the Mygind position, the wide natural ostium created by FESS usually stays above the level of the instilled fluid. However, as mentioned before, the amount of fluid by Roh et al and ours were different regarding the quantity of instilled fluid and the study specimens.

Although the fluid should flow into the dependent sinonasal areas, there were some cadavers in our study showing no deposition of fluid in some dependent areas. For example, in the Mygind position after FESS, we should be able to detect the fluid in all sphenoid sinuses. However, our study could detect only 7 out of 8. It may be explained that the instilled saline could form the film coating over the sinus outflow tract because the nasal instillation was a low pressure technique, not like using irrigation or using a squeeze bottle which used high pressure.

The advantage of this present study was to demonstrate that a large volume saline instilled intranasally can deliver fluid to the dependent parts of sinonasal areas by flow of the saline along the side wall of nasal cavities. This method of delivery allows topical medications, for example steroid in saline, contact with the sinonasal mucosa as long as the head position is held for a specific period of time. This is different from the use of nasal irrigation in post-FESS patients which the fluid will remain in sinonasal cavities less than 5%, the rest will go into the basin<sup>(6)</sup>. Although there are other studies on nasal instillation/drop, they used a few nasal drops which may not have enough volume of medications to cover the specific sinonasal mucosa.

The limitation of this study was the shrinkage of sinonasal mucosa of the cadavers which might facilitate the flow of the fluid into sinonasal areas, especially in pre-FESS cases more than in human beings. Even we cleaned the sinonasal cavities before nasal instillation, there might be some debris or necrosis tissue in cadavers left in sinonasal tract that might impede the distribution of the fluid. Therefore, the distribution of the fluid by a large volume saline by nasal instillation should be further conducted in normal volunteers and patients after the sinus surgery.

## Conclusion

This is the first study of a large volume saline by nasal instillation to determine the distribution of

fluid into sinonasal locations. It may be applied to patients who have inflammatory sinonasal diseases in specific sinonasal locations by using a specific head position to deliver medications to the specific areas. If we would like to deliver a topical steroid to the olfactory cleft, we can use any of the three positions. In patients after FESS, the vertex-to-floor position is the best position to deliver topical medications to the frontal and anterior ethmoid sinuses, while the Mygind position is the best position to deliver topical medications to the posterior paranasal sinuses, and the Ragan position is the best position for the maxillary sinus.

## What is already known on this topic?

There have no previous studies conducted on the sinonasal deposition of a large volume saline delivered by nasal instillation.

## What this study adds?

This is the first study on the sinonasal deposition of a large volume saline delivered by nasal instillation.

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## Potential conflicts of interest

None.

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ความสามารถในการที่น้ำเกลือเข้าไปในไซนัสต่าง ๆ โดยการหยอดน้ำเกลือปริมาณมากในศีรษะท่าต่าง ๆ

สงวนศักดิ์ ธนาวิรัตนกิจ, สิริสุทธิ เรืองผลวิวัฒน์, วรินทร์ พุทธิรักษ์, พรเทพ เกษมศิริ, โกวิท ไชยสีวามงคล

**วัตถุประสงค์:** เพื่อศึกษาการกระจายของน้ำเข้าไปในไซนัสและโพรงจมูกจากการหยอดน้ำเกลือปริมาณมาก ผ่านทางโพรงจมูกในศพสดแช่แข็ง เมื่อจัดศีรษะให้อยู่ในท่าต่างๆ

**วัสดุและวิธีการ:** เป็นการศึกษาวิจัยแบบทดลองในศพสดแช่แข็ง fresh จำนวน 4 ร่าง โดยหยอดน้ำเกลือผสม สารทึบแสงเข้าไปในโพรงจมูก เมื่อจัดศีรษะใน 3 ท่า (ท่า Mygind, vertex-to-floor และ Ragan) ทั้งก่อนและหลังการผ่าตัดไซนัสผ่านกล้องส่องจมูก (FESS) ประเมินการที่น้ำเกลือเข้าไปในโพรงจมูกและไซนัสด้วยการภาพรังสีคอมพิวเตอร์ชนิด Cone beam

**ผลการศึกษา:** ศีรษะท่า vertex-to-floor และ Mygind สามารถส่งน้ำเกลือเข้าไปอยู่ใน olfactory cleft, sphenoethmoidal recess และ frontal recess ทั้งก่อนและหลังการผ่าตัด FESS, หลังผ่าตัด FESS ศีรษะท่า vertex-to-floor สามารถส่งน้ำเกลือเข้าไปในไซนัสเอทมอยด์ส่วนหน้าและไซนัสฟรอนทัลมากกว่าไซนัสอื่น ในขณะที่ศีรษะท่า Mygind สามารถส่งน้ำเกลือเข้าไปในไซนัสฟีนอยด์, ไซนัสเอทมอยด์ส่วนหลัง และส่วนหน้ามากกว่าไซนัสแมกซิลลารีและไซนัสฟรอนทัลสำหรับศีรษะท่า Ragan ส่งน้ำเกลือเข้าไปใน olfactory cleft และ sphenoethmoidal recess มากกว่า frontal recess ทั้งก่อนและหลัง FESS, หลังผ่าตัด FESS ศีรษะท่า Ragan ส่งน้ำเกลือเข้าไปในไซนัสแมกซิลลารีได้มากกว่าศีรษะท่าอื่นๆ

**สรุป:** การศึกษานี้เป็นการศึกษาแรกที่ประเมินการเข้าไปอยู่ภายในตำแหน่งไซนัสและโพรงจมูกหลังการหยอดน้ำเกลือ ปริมาณมากทางจมูก การศึกษานี้พบว่าการจัดศีรษะในท่าต่างๆ มีผลต่อตำแหน่งการเข้าไปอยู่ของน้ำเกลือ ผลการศึกษานี้จะนำไปประยุกต์ใช้สำหรับผู้ป่วยเพื่อเป็นการนำยาเฉพาะที่เข้าไปอยู่ในตำแหน่งเฉพาะของโพรงจมูก และไซนัสเพื่อเพิ่มการสัมผัสของเยื่อบุกับยาให้นานครบเท่าที่ยังจัดศีรษะให้อยู่ในท่าที่เหมาะสม

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