The Validity of Peak Nasal Inspiratory Flow as a Screening Tool for Nasal Obstruction

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Background: *The peak nasal inspiratory flow (PNIF) is used as an outcome measure in post-treatment clinical and research evaluation. It is simple and cost effective. The validity of the use as a screening tool has never been assessed.*
Objective: *To assess its validity and to define the cut-off point of determining the nasal obstruction*
Material and Method: *The nasal patency of 141 ambulatory subjects with or without sino-nasal diseases was measured by the PNIF and active anterior rhinomanometry. Inclusion criteria was all subjects aged 18 to 75-years-old, sinonasal diseases/ symptoms(nasal congestion, nasal discharge, nasal polyp, deviated nasal septum, nasal tumor, inferior turbinate hypertrophy, sinusitis, and allergic rhinitis), instant sensation of nasal obstruction, and nasal endoscopy finding were recorded. All subjects signed written consent. Compared with the active anterior rhinomanometry as the gold standard, the sensitivity, specificity, likelihood ratio, positive predictive value, and negative predictive value of the PNIF was analyzed. The cut-off point of nasal obstruction was defined from the Receiver Operating Characteristic curve analysis. The agreement between the PNIF and the stuffiness and between the PNIF and the presence of sino-nasal diseases were assessed by using Kappa.*
Results: *With the cut-off point of 90 L/min, the sensitivity of the peak nasal inspiratory flow was 0.87 (0.753-0.989). The specificity was 0.52 (0.429-0.617). The negative predictive value was 0.93 (0.872-0.997). The positive predictive value was 0.34 (0.237-0.446). The likelihood ratio was 1.81 (1.438-2.318). The mean of the PNIF in normal subjects was 97.11 ± 31.15. The agreement between the PNIF and the instant sensation of nasal blockage was 0.14 (-0.024-0.321) and the agreement between the PNIF and the sino-nasal diseases was 0.09 (-0.083-0.265).*
Conclusion: *The PNIF, regarding the cut-off point of 90 L/min, revealed good sensitivity and high negative predictive value but it had low specificity and low positive predictive value. The nasal peak flow did not agree well with the subjects' symptoms of blockage and sino-nasal diseases.*

Keywords: *Peak nasal inspiratory flow, Active anterior rhinomanometry (AAR), Cut point, Sensitivity, Specificity, Receiver operating characteristic curve analysis*

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The nasal patency can be evaluated by many ways with various tools. The three most popular tools are rhinomanometry, acoustic rhinometry, and peak nasal inspiratory flow (PNIF). Although all of these three tools are to define the degree of nasal obstruction, they actually investigate three different parameters. Rhinomanometry measures the nasal resistance, which can be done actively or passively and anteriorly or posteriorly. Posterior rhinomanometry assesses the total nasal resistance whilst anterior rhinomanometry evaluates each side resistance and the total resistance can be obtained by calculation. Acoustic rhinometry measures the minimal cross sectional area and the nasal volume. The PNIF measures the peak inspiratory flow rate. The good nasal patency is assumed to have a low nasal resistance, a high nasal volume, and a high peak flow. It is not yet concluded which of the three parameters is the most accurate to predict the nasal patency. However, both acoustic rhinometry and posterior rhinomanometry are relatively difficult and require trained personnel to perform. The error of acoustic rhinometry may be caused by the wrong probe position and the acoustic leak[1]. Posterior rhinomanometry has a technical difficulty and more requires an adequate patients' cooperation so that it may be impossible to perform in some cases.

The advantages of PNIF are simplicity, portability, and economy. It has been used for the evaluation of medical and post-surgical therapy in both

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clinics and researches. In addition, the PNIF can also be used as a screening tool for nasal obstruction because the subjective sensation of nasal blockage sometimes seems unreliable. Most patients who have a chronic nasal obstruction may not realize their nasal occlusion. Some patients with good nasal patency may complain about annoying stuffiness possibly due to decreased sensation of the fifth cranial nerve, decreased sensation of breathing, post-surgical empty nose, a disturbance of turbulent and laminar flow or atrophic nasal mucosa. The objectives of the present study were to assess the validity of peak nasal inspiratory flow and to determine the cut point for the nasal obstruction for the screening purpose. The authors would also like to assess the agreement between the PNIF and the instant sensation of nasal blockage and the agreement between the PNIF and the presence of sino-nasal diseases.

Material and Method

The protocol was approved by the Institutional Review Board and the Ethics Committee of Chulalongkorn University. The authors recruited the subjects by a poster announcement. The participants were any ambulator who had a good general health with or without sino-nasal diseases. Informed consents were obtained from all participants. The nasal patency was measured by the PNIF (In-Check Nasal, Clement Clarke International, United Kingdom) and active anterior rhinomanometry (AAR) (Interacoustics, Denmark). The subjects would be instructed how to sniff correctly for the peak nasal flow measurement and tried it until each had an appropriate performance. Both PNIF and AAR would be tested for three times each. The mean peak nasal inspiratory flow and the mean total nasal resistance of each subject were calculated and used for the analysis. All subjects underwent nasal endoscopy. Sino-nasal symptoms and the instant sensation of nasal obstruction were recorded. They were clinically diagnosed based on the evidences from the symptoms and the endoscope findings as either normal or specified sino-nasal diseases. The cut point of the PNIF to determine the nasal obstruction was defined from the Receiver Operating Characteristic curve analysis. The AAR was defined normal when the total nasal resistance was 0.13-0.84 Pas/cm^3/s[2]. Compared with the AAR as the gold standard, the sensitivity, specificity, likelihood ratio, positive predictive value, negative predictive value of the PNIF was analyzed. The agreement between the PNIF and the stuffiness and between the PNIF and the presence of sino-nasal diseases were assessed.

The SPSS statistical software (version 13.0 for Windows, APACHE) was used for data analysis. The sample size was determined based on the pilot data where we assumed the sensitivity of 0.75 and the acceptable error of 0.15. The prevalence of sino-nasal diseases in general patients in our clinic was around 30%. The sample size should be $(1.96)^2$ (0.75) (0.25)/ $(0.15)^2$/(0.30) which was 107. Kappa was used for the agreement analysis[15].

Results

One hundred forty one subjects were enrolled in the present study and included 35 men (24.8%) and 106 women (75.2%). The age ranged from 18 to 72-years-old. The mean age was 40.59. Thirty-nine (27.7%) reported that they had nasal obstruction at the time of the present study while one hundred and two (72.3%) felt free of blockage. Sino-nasal diseases were diagnosed in one hundred and two (72.3%). Some subjects had more than one diagnosis. Seventy-six subjects were clinically diagnosed as allergic rhinitis. Other diagnosis included rhinosinusitis (10 subjects), vasomotor rhinitis (4 subjects), nasal polyp (2 subjects), and benign neoplasm (1 subject).

The total nasal resistance was normal in 110 subjects (78%). The range of all subjects was between 0-2.4 Pas/cm^3/s. The mean total nasal resistance was 0.37 ± 0.27 Pas/cm^3/s. Correlation with one study from Thailand in 1995, showed asymptomatic normal nasal airway resistance = 0.22 ± 0.10 Pas/cm^3/s[14].

The cut point for the screening purpose was defined 90 L/min from the Receiver Operating Characteristic curve analysis (Fig. 1). With the cut point of 90 L/min, the subjects were divided into normal group whose nasal peak flow was not less than the cut point and the abnormal group whose nasal peak flow was below that point as displayed in Table 1. The

Table 1. A comparison between the number of the normal and abnormal groups, assessed by PNIF (Peak Nasal Inspiratory Flow) and AAR (Active Anterior Rhinomanometry)

	AAR		Total
	Normal	Abnormal	
PNIF			
Normal (≥ 90 L/min)	27	52	79
Abnormal (< 90 L/min)	4	57	61
Total	31	109	140*

*one woman was missing AAR value

Table 2. True positive rate (sensitivity) and false positive rate (1-specificity) of various cut points of the PNIF (Peak Nasal Inspiratory Flow)

PNIF (L/min)	29.0	51.0	81.0	90.0	99.0	105.0	111.0	183.0	201.0
Sensitivity	0	0.32	0.77	0.87	0.93	0.97	1.00	1.00	1.00
1-specificity	0	0.12	0.41	0.48	0.58	0.68	0.72	0.98	1.00

sensitivity of the peak nasal inspiratory flow was 0.87 (0.753-0.989). The specificity was 0.52 (0.429-0.617). The negative predictive value was 0.93 (0.872-0.997). The positive predictive value was 0.34 (0.237-0.446). The likelihood ratio was 1.81 (1.438-2.318). The participants who had no abnormality by history and endoscopic finding and free of nasal stuffiness were defined as normal. The PNIF of the normal subjects was ranged from 40 to 173 L/min. and the mean of the PNIF in normal subjects was 97.11 ± 31.15. Whilst the PNIF in all subjects ranged from 30-200 L/min and the mean PNIF was 86.80 ± 33.6 L/min. The agreement between the PNIF and the instant sensation of nasal blockage was 0.14 (-0.024-0.321) and the agreement between the PNIF and the sino-nasal diseases was 0.09 (-0.083-0.265).

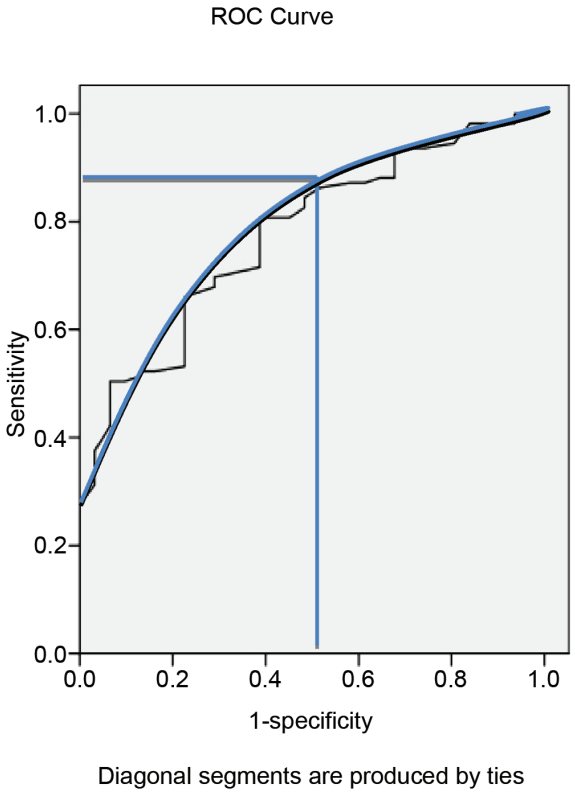

Fig. 1 The receiver operating characteristic curve analysis of the PNIF to screen the nasal obstruction

Discussion

The use of PNIF is now increasing because it is simple and cost-effective. Many researchers evaluated the study outcomes by the assessment of PNIF improvement. Several studies evaluated the PNIF for the efficacy of intranasal corticosteroids therapy in allergic rhinitis[3,4] and nasal polyposis[5,6]. For the post-surgical evaluation, some authors examined the PNIF as an objective measurement of the result of endoscopic sinus surgery[7], septoplasty[8], and laser surgery[9]. The use of PNIF for screening the nasal obstruction is not widely used as its validity for this purpose has never been assessed. Regarding the Receiver Operating Characteristic curve analysis of the present study, the authors found that at the cut point of 90 L/min, the PNIF has a good sensitivity of 0.87 (0.753-0.989), a high negative predictive value of 0.93 (0.872-0.997) with a fair specificity of 0.52 (0.429-0.617) and low positive predictive value of 0.34 (0.237-0.446). Clinicians may increase the cut point up to more than 99 L/min to achieve more sensitivity of more than 0.93 with decreased specificity, depending on various contexts, experiences, and purposes (Table 2).

Several studies previously assessed the sensitivity of the PNIF but those study designs were to evaluate if it was sensitive to detect the change of nasal patency. Hellegren et al compared the ability of the PNIF with acoustic rhinometry and rhinomanometry in detecting the nasal changes after histamine challenge and they found that the PNIF was the most sensitive[10]. Wilson et al proposed the same result that the PNIF was more sensitive than acoustic rhinometry and rhinomanometry in detecting corticosteroids response with nasal histamine challenge[11].

Both of the agreements between the PNIF and the instant sensation of nasal blockage and between the PNIF and the sino-nasal diseases were quite low (0.14 (-0.024-0.321) and 0.09 (-0.083-0.265) respectively). The results contradicted the previous study by Gleeson et al. They reported a more correlation (r = 0.54) with the sensation of nasal obstruction[12]. This was possibly due to dissimilarity of the methodology between the two studies. Gleeson investigated the subjective sensation after topical

administrations with histamine and cocaine while the present study examined subjects with a longer duration of nasal obstruction. The authors believe the subjective stuffiness sensation should be more reliable in acute nasal obstruction. Most people tolerate with a chronic nasal blockage and their complaints were usually less than the severity of nasal congestion they really have. The anterior rhinometry was also proposed by a previous study to correlate poorly with the subjective sensation of nasal patency[13].

Conclusion

With a cut-off point of 90 L/min, the PNIF had a good sensitivity and a high negative predictive value but it had a low specificity and a low positive predictive value. The nasal peak flow did not agree well with the subjects' symptoms of blockage and sino-nasal diseases.

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Potential conflicts of interest

None.

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Appendix.

No _____

Date _____

CRF: การศึกษาหาค่าปกติ ความไว และความจำเพาะของ PNIF

CODE _____ เพศ _____ อายุ _____

Symptoms

- ☐ คัดแน่นจมูก
- ☐ จาม
- ☐ น้ำมูกใส
- ☐ คันจมูก
- ☐ มีกลิ่นเหม็น
- ☐ ปวดจมูก
- ☐ ปวดใบหน้า
- ☐ ปวดหู
- ☐ ปวดฟัน
- ☐ ได้กลิ่นลดลง / ไม่ได้กลิ่น
- ☐ ไข้
- ☐ มูกลงคอ/ เสมหะ
- ☐ น้ำมูกเหลืองเขียว
- ☐ ไอ

Sign

- ☐ nasal congestion
- ☐ watery nasal discharge
- ☐ Mucoid / purulent discharge
- ☐ DNS, not affecting to nasal valve
- ☐ DNS, affecting to nasal valve
- ☐ nasal polyp
- ☐ nasal tumor / mass
- ☐ IT hypertrophy

Diagnosis:

- ____ Normal
- ____ Diseases
  1. DNS affecting to nasal valve
  2. AR
  3. Sinusitis
  4. NP
  5. Tumor / mass
  6. IT hypertrophy

☐ Rhinomanometry

PNIF

1	2	3	MEAN

ค่าที่เหมาะสมของเครื่อง peak nasal inspiratory flow เพื่อการคัดกรองภาวะคัดจมูก

วลิน รุจนเวชช์, กรเกียรติ์ สนิทวงศ์, สุพินดา ชูสกุล, ทรงกลด เอี่ยมจตุรภัทร

ภูมิหลัง: เครื่อง peak nasal inspiratory flow (PNIF) เป็นเครื่องมือที่ใช้วัดผลหลังผ่าตัดโพรงจมูกและในการทำวิจัย ใช้ง่ายและคุ้มค่า แต่ในการใช้เป็นเครื่องมือคัดกรองภาวะคัดจมูกยังไม่มีการนำมาใช้

วัตถุประสงค์: เพื่อประเมินความถูกต้องของค่า PNIF และเพื่อกำหนดค่าจุดตัด (cut point) ที่เหมาะสมต่อการคัดกรองภาวะคัดจมูก

วัสดุและวิธีการ: บันทึกข้อมูลจากโพรงจมูก ในผู้เข้าร่วมการวิจัย 141 คน ทั้งที่มีและไม่มีโรคโพรงจมูกและไซนัสด้วยเครื่อง PNIF and active anterior rhinomanometry (AAR) เกณฑ์การคัดเลือกผู้เข้าร่วมการวิจัย: อายุ 18-75 ปี มีโรคโพรงจมูกและไซนัส (มีอาการ) เช่น คัดจมูก น้ำมูก ริดสีดวงจมูก ผนังจมูกคด เนื้องอก เยื่อจมูกบวม ไซนัสอักเสบ ภูมิแพ้ มีความรู้สึกคัดจมูกขณะตรวจและบันทึกการส่องกล้องตรวจในโพรงจมูก ผู้เข้าร่วมการวิจัยทุกคนลงนามในใบยินยอม เปรียบเทียบผลที่ได้กับ AAR ซึ่งเป็นมาตรฐานในการวินิจฉัย นำมาวิเคราะห์หาค่าความไว ความจำเพาะ จำนวนเท่าที่ผลการทดสอบดังกล่าวจะพบในคนที่คัดจมูกเมื่อเปรียบเทียบกับคนที่ไม่คัดจมูกค่าพยากรณ์บวก ค่าพยากรณ์ลบของ PNIF ค่าจุดตัดที่เหมาะสมโดยวิเคราะห์จาก Receiver Operating Characteristic curve ใช้ Kappa วัดความสอดคล้องกันระหว่าง PNIF กับภาวะคัดจมูก และระหว่าง PNIF กับการมีโรคโพรงจมูกและไซนัส

ผลการศึกษา: ที่ค่าจุดตัดที่ 90 L/min จะได้ค่าความไวของ PNIF เท่ากับ 0.87 (95% CI 0.753-0.989) ค่าความจำเพาะของ PNIF เท่ากับ 0.52 (95% CI 0.429-0.617) ค่าพยากรณ์ลบของ PNIF เท่ากับ 0.93 (95% CI 0.872-0.997) ค่าพยากรณ์บวกของ PNIF เท่ากับ 0.34 (95% CI 0.237-0.446) จำนวนเท่าที่ผลการทดสอบดังกล่าวจะพบในคนที่คัดจมูกเมื่อเปรียบเทียบกับคนที่ไม่คัดจมูกเท่ากับ 1.81 (1.438-2.318) ค่าเฉลี่ยในคนปกติเท่ากับ 97.11 ± 31.15 ความสอดคล้องกันระหว่าง PNIF กับความรู้สึกคัดจมูกขณะตรวจเท่ากับ 0.14 (-0.024-0.321) ความสอดคล้องกันระหว่าง PNIF กับการมีโรคโพรงจมูกและไซนัสเท่ากับ 0.09 (-0.083-0.265).

สรุป: ที่ค่า 90 L/min ของเครื่อง Peak Nasal Inspiratory Flow จะได้ค่าความไวของ PNIF ที่ดี และค่าพยากรณ์ลบของ PNIF ที่สูง แต่ค่าความจำเพาะของ PNIF ที่ต่ำ ค่าพยากรณ์บวกที่ต่ำ เครื่อง PNIF ไม่มีความสอดคล้องที่ดีต่อความรู้สึกคัดจมูกขณะตรวจ, โรคโพรงจมูก และไซนัส