Nasal Model and Lung Model Machine for Intranasal Stent with Filters Efficacy Evaluation

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Abstract

Nasal model and lung model machine simulated human respiratory situation with cyclical air flow rate of 2 l/min. They were used to evaluate filtration efficacy of filters in an intranasal stent for laser smoke particles in the Otolaryngology Department, Ramathibodi Hospital from February to June 1998. The filters were three layers of half face mask outer filters. Each of five sets or 10 intranasal stents with filters or Whatman filters was attached at both inlet ends of the nasal model. A Whatman filter collected the maximum particle amount from 10 shots, 10 W and 0.2 s of single pulse mode carbon dioxide laser evaporative field for 5 min which was the same amount passed through filters of the intranasal stent. A high power optical microscope was used to count particle retention in each filter. The mean filtration efficacy of filters in the intranasal stent was 94.4 per cent when compared with that of the Whatman filter. A personal respiratory protective device could be applied in the human nasal vestibule to prevent polydisperse suspended particulate matter in a highly air-polluted area. The nasal model with lung model machine should be tested under different concentrations of laser smoke particles or at the main roadside.

Key words : Nasal Model, Lung Model Machine, Intranasal, Stent, Filter, Efficacy, Laser Smoke Particle

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An intranasal stent with filters has been proposed for atmospheric suspended particulate matter prevention with acceptable nasal air flow resistance and comfortable usage(1). The device application in the human nasal vestibule is a personal respiratory protective device while travelling by public transportation in a highly air-polluted zone. The atmospheric suspended particulate matter amount at several main roadsides in Bangkok has increased to three times above the standard level(2).

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Half face, surgical, dust filter or nuisance mask is not effective due to leakage of particles between the facial skin and the mask, discomfort and improper mouth usage. The mean leakage and penetration of the facial half mask are 0 - 63.0 per cent and 0.6 - 39.0 per cent respectively[3-5]. The efficacy of the intranasal stent with filters could be evaluated in a polydisperse laser smoke particle environment[6,7]. The device was tested with the nasal model and lung model machine which created cyclical air flow like that in a human respiratory function situation[8,9].

MATERIAL AND METHOD

The nasal model was made of Y- type hollow plastic material, 9.5 cm in length and 5.5 in width. There were two inlets 1.5 cm in diameters and one outlet 2.0 cm in diameter. Each of the 5 sets or 10 Whatman filters (Grade 1, Whatman Group, U.S.A.) was fitted in the middle inner 0.2 cm ridge of the nasal model inlets with two 4 cm in length, hollow, cylindrical, plastic filter adapters (Fig. 1). The nasal model outlet end was connected to the lung model machine inlet which was used as an air sampling instrument (Model FP1, dynamic calibration for NR6-2 rhinomanometer, Mercury Electronics Ltd, Scotland). The cyclical air flow of 2 l/min was measured by a respirometer (Model RM121, Ohmeda, BOC Health Care, Japan). Each of the 5 sets or 10 intranasal stents with filters was attached to the two inlet ends of the nasal model (Fig. 2). The stent was hollow, cylindrical, medical grade silicone. The stent length was an 0.5 cm with an outer diameter of 1.3 cm and inner diameter of 1.1 cm. Two filters and one layer of outer layers of the half face or surgical mask were sealed at each end of the intranasal stent (Fig. 3). The middle layers of the face mask created too high air flow resistance. The experiment was conducted in the Otolaryngology Department, Ramathibodi Hospital from February to June 1998. Laser smoke particles came from 10 shots of a single pulse mode, 10 W and 0.2 sec of a carbon dioxide laser (Model 1060, Sharplan, Laser Industries Ltd, Tel Aviv, Isarael). Each set of filters was run for 5 min to get laser smoke particles in a sealed plastic box with the specimen put inside (Fig. 4). The particle amount was examined under a 10 x 40 optical microscope with a field area of 0.0013 cm^2. The active filtration area of each filter was 0.9507 cm^2. Ten defined areas of laser smoke particle counts in each filter were

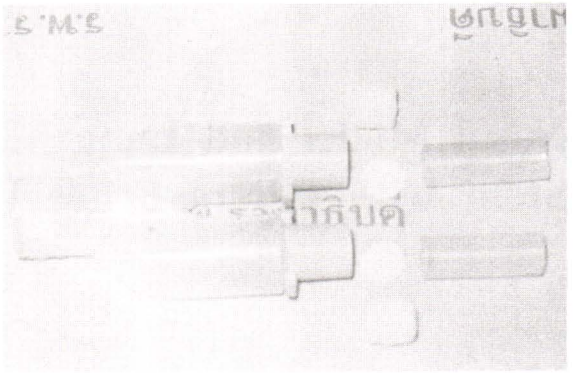

Fig. 1. Nasal model was on the left; Whatman filter was at the center; filter adapter was on the right.

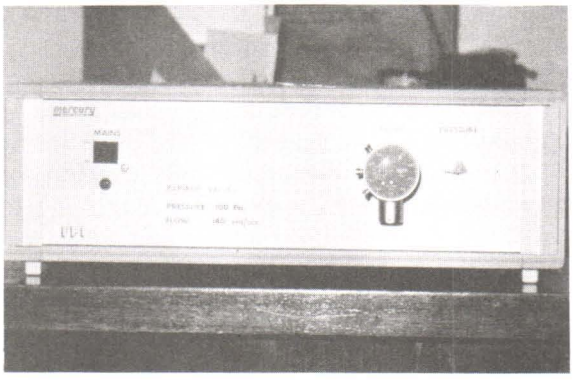

Fig. 2. Lung model machine inlet was connected with respirometer (or outlet of the nasal model).

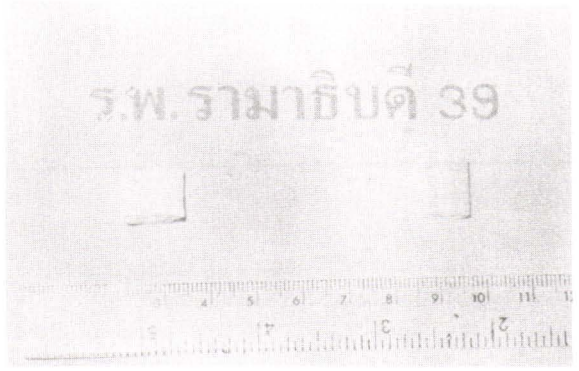

Fig. 3. Intranasal stent was on the left; outer layers of face half mask filters was at the center; intranasal stent with filter was on the right.

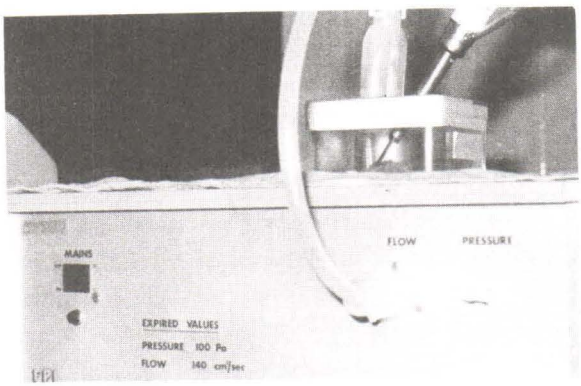

Fig. 4. Nasal model was connected with two openings at the top of plastic box ; the other opening of the plastic box was for laser handpiece ; plastic box for laser evaporation with specimen inside was on the top of lung model machine.

multipiled by 73.1308 to get the total particle amount.

RESULT

Under cyclical air flow from the nasal model and lung model machine, the filtration efficacy of three - layer filters with an intranasal stent compared with that of the Whatman filter was 94.4 per cent (Table 1). The laser smoke particles were from a polydispersed suspended particulate matter source. The Whatman filter got the maximum laser smoke particle amount from the laser evaporative field. The particles in the laser evaporative field were 9.4 particles / cm^3. The laser smoke particles which passed through each Whatman filter or filter in the intranasal stent were the same in amount. The difference between the particle or air flow rate between each inlet end of the nasal model was 29.7 per cent for the Whatman filter and 22.7 per cent for the intranasal stent with filters (Table 1).

DISCUSSION

The nasal model mimicked the human nasal cavity, nasopharynx, oropharynx and hypopharynx. The air flow which passed through each inlet end of the nasal model did not differ significantly from that in the human nasal cycle[10]. The lung model machine was adjusted according to the human sinusoidal respiratory pattern. The normal respiratory range with a tidal volume of 500 ml to 1,000 ml and respiratory rate of 15-20 /min should be considered[11]. The intranasal stent with filters should be applied in the human nasal vestibules during high concentrations of suspended particulate matter at the main roadsides in Bangkok[12]. Laser smoke particles have suitable polydisperse atmospheric suspended particulate matter[6]. Dust is composed of various sizes and shapes of particles with a diameter range of 2 - 500 um[13-15]. The particle size of 0.5 - 15 um is considered to include inhalable and respirable particulate[16,17]. The effect of environmental contamination was minimum because the experiment was done in an air conditioned operative room.

Table 1. Laser smoke particle deposition* in 5 sets of the Whatman filter and intranasal stent with filters through both inlets of the nasal model.**

Set No.	Whatman filter		Intranasal stent with filters	
	Right***	Left	Right	Left
1	696	492	878	342
2	766	467	569	432
3	724	527	685	629
4	731	595	625	605
5	845	563	651	628
mean (each side)	752.4	528.8	681.6	527.2
mean+/-S.D. (both side)	1,281.2 +/- 86.6		1,208.8 +/- 122.2	

* Ten fields under 10x40 optical microscope;

** Each set had 2 Whatman filters or 2 filters in the intranasal stent, sinusoidal air flow rate of 2 l/min for 5 min;

*** Right and left side of the nasal model

Particles in the filter of the intranasal stent were partially lost while preparing the filter for optical microscopic examination. The Whatman filter has more solidity properties than filters of the intranasal stent and is commonly used in air-pollution monitering. The filters of intranasal stent had 10 focal levels under the 10x40 optical microscope while the Whatman filter had only 5 focal levels (18). More accurate particle counting instruments should be used. Others filter material in the intranasal stent should be tried to get a higher filtration efficacy. Polyurethane foam has a 97 per cent porosity void space, is relatively tough, extremely high dust holding, is of the proper thickness and very low air flow resistant. It could be molded in a special shape and washed out with water and detergent. There is a report of carcinogenic induction in animal experiments(19). Experiments with various concentrations of laser smoke particles or field study in humans should be done.

SUMMARY

The lung model machine created cyclical air flow through the nasal model which mimicked the human respiratory system. The intranasal stent with three outer layers of half face mask filters attached at both inlet ends of the nasal model was proposed as a personal respiratory protective device. The device filtration efficacy tested with 10 shots, 10 W and 0.2 s single pulse mode of carbon dioxide laser smoke particles was 94.4 per cent when compared with that of the Whatman filter. Other filter materials, different laser smoke particle concentrations and a field study in humans should be investigated further

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การใช้หุ่นจำลองจมูกและเครื่องจำลองปอดเทียมเพื่อประเมินประสิทธิภาพของเครื่องถ่างช่องจมูกพร้อมแผ่นกรอง

*ครรชิตเทพ ตั้นเผ่าพงษ์, พ.บ.**

การใช้หุ่นจำลองจมูกและเครื่องจำลองปอดเทียมเพื่อเลียนแบบการทำงานของระบบทางเดินหายใจของมนุษย์ด้วยการทำให้เกิดการไหลเวียนของอากาศชนิด cyclical ในปริมาณ 2 ลิตรต่อนาที เพื่อทดลองประสิทธิภาพของเครื่องถ่างช่องจมูกซึ่งมีแผ่นกรองอากาศที่ทำจากหน้ากากที่ใช้ในห้องผ่าตัดที่นำมาติดที่ปลายทั้งสองข้างสำหรับฝุ่นจากการเผาไหม้ของเลเซอร์ กับเครื่องถ่างช่องจมูกที่มีแผ่นกรอง Whatman ปิดที่ส่วนปลาย ณ ภาควิชาโสต นาสิก ลาริงซ์วิทยา คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี ระหว่างกุมภาพันธ์ ถึงมิถุนายน พ.ศ. 2541 การศึกษานี้พบว่า แผ่นกรอง Whatman 5 ชุดหรือ 10 แผ่น กรองฝุ่นปริมาณสูงสุดจากบริเวณที่มีการเผาไหม้ของคาร์บอนไดอ๊อกไซด์เลเซอร์ชนิด single pulse mode กำลัง 10 วัตต์ ในระยะเวลา 0.2 วินาที จำนวน 10 ครั้ง เมื่อตรวจนับฝุ่นที่แผ่นกรองด้วยกล้องจุลทรรศน์กำลังขยายสูง พบว่าประสิทธิภาพการกรองฝุ่นของแผ่นกรองที่ติดกับเครื่องถ่างช่องจมูกจำนวน 5 ชุดหรือ 10 แผ่นสูงถึงร้อยละ 94.4 เมื่อเปรียบเทียบกับแผ่นกรอง Whatman ผลการศึกษานี้แสดงให้เห็นว่าเครื่องถ่างช่องจมูกที่ประดิษฐ์ขึ้นมาใหม่นี้อาจนำมาใช้ในการป้องกันมลพิษในอากาศ โดยการนำเอาเครื่องดังกล่าวนี้ใส่ในช่องจมูกส่วน vestibule ของผู้ใหญ่ในกรณีที่มีอนุภาคมลพิษปริมาณมาก อย่างไรก็ดีควรมีการศึกษาเพิ่มเติมเกี่ยวกับประสิทธิภาพของเครื่องมือดังกล่าวในสภาพที่มีฝุ่นจากการเผาไหม้ของเลเซอร์ ปริมาณต่างๆกันหรือบริเวณริมถนนที่มีการจราจรหนาแน่น

คำสำคัญ : หุ่นจำลองช่องจมูก, เครื่องจำลองปอดเทียม, ช่องจมูก, เครื่องถ่าง, แผ่นกรอง, ประสิทธิภาพ, ฝุ่นจากการเผาไหม้ของเลเซอร์

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