Efficacy of Intranasal Stent with Filters for Different Laser Smoke Particle Concentration

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Abstract

Intranasal, hollow, cylindrical, medical grade, silicone stent with two layers and one layer of half face mask outer filter at each end was tested with different concentrations of laser smoke particles. A single pulse mode of carbon dioxide laser smoke particle created suitable polydisperse atmospheric suspended particulate matter amount. The personal respiratory protective device efficacy was done at the Otolaryngology Department, Ramathibodi Hospital from July to September 1998. The Whatman filter had the same laser smoke particle amount that passed through each filter of the intranasal stent. The cyclical air flow rate of 2 l/min in the nasal model was controlled by a lung model machine and respirometer. The particle deposition in filter materials was counted under a high power optical microscope. The filtration efficacy of an intranasal stent with filters for 5, 10 and 20 shots of laser smoke particle were 90.5, 94.6 and 95.6 per cent respectively with a mean of 93.6 per cent. The device application in a human nasal vestibule depended on acceptable nasal air flow resistant in various highly air-polluted areas.

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

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Intranasal stent with filters as a personal respiratory protective device has been reported[1]. The filters are the outer layers of a half face mask or surgical mask which is very popular. The mask is sealed around the mouth and nose creates a high nasal air flow resistance due to its middle paper layers[2-4]. The device should be used in highly air-polluted areas[5,6]. Laser smoke particles are composed of suitable polydisperse atmospheric suspended particulate matter[7,8]. The filtration efficacy of the intranasal stent with filters for continuous air flow pattern was in consideration. The

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filtration efficacy of filters in the intranasal stent for different laser smoke particle concentrations was evaluated under cyclical air flow conditions like that in the human respiratory system.

MATERIAL AND METHOD

The experiment was conducted at the Otolaryngology Department, Ramathibodi Hospital from July to September 1998. Ten intranasal stents with filters for each 5, 10 and 20 laser shots or a total of 30 intranasal stents with filters were used. The length of each intranasal stent was 1.0 cm with 1.3 cm outer diameter and 1.1 cm inner diameter. Two layers and one layer of the outer layers of a half face mask were sealed at each end of the intranasal stent with adhesive tape. The nasal model was Y-type hollow plastic, 9.5 cm in length and 5.5 cm in width. There was one 2.0 cm in diameter outlet and two 1.5 cm in diameter inlets. The intranasal stents with filters were attached at both inlet ends of the nasal model (Fig. 1). The maximum laser smoke particles were collected by 30 Whatman filters each of 1.3 cm in diameter (Grade 1, Whatman Group, U.S.A.) which fitted in the middle inner 1.3 cm in diameter circular ridge of the nasal model with two hollow plastic filter adapters. The nasal model outlet was connected to the inlet of a lung model machine (FP1 Dynamic calibration for NR6-2 rhinomanometer, Mercury Electronic Ltd., Scotland). The cyclical air flow rate of 2 l/min from FP1 was measured by a respirometer (Model RM121, Ohmeda, BOC Health Care, Japan). The particle amount created by a single pulse mode, 10 W, 0.2 s duration and 5, 10 and 20 shots of carbon dioxide laser (Model 1060, Sharplan, Laser Industries Ltd, Tel Aviv, Isarael) was confined in a sealed, 7 X 7 X 7 cm, plastic box with the specimen inside. Three 1.5 cm diameter holes at the top of the box were for the laser handpiece and nasal model inlets (Fig. 2). Each test was run for 5 minutes. A laser plume evacuator was used to clear residual laser smoke particles from the plastic box, nasal model and lung model machine prior to the next test (Fig. 3). Ten defined fields of particle reten-

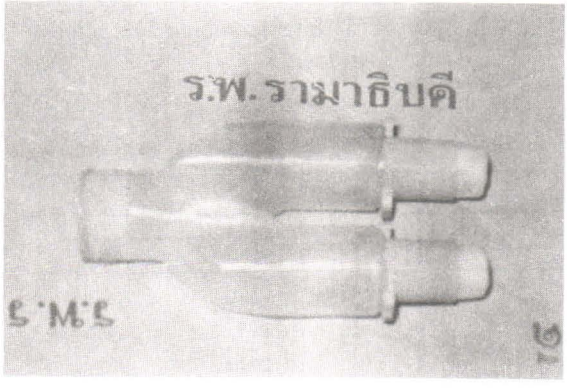

Fig. 1. Intranasal stent with filters on the right connected to inlets of the nasal model on the left.

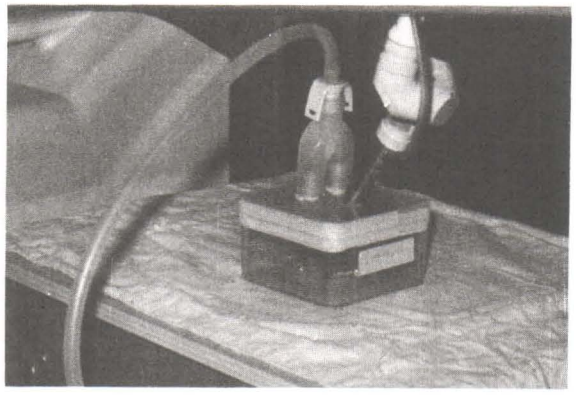

Fig. 2. Plastic box with specimen for laser smoke particle confinement during laser evaporation at the center; laser hand-piece at the left of the top wall of the box with the nasal model on the right.

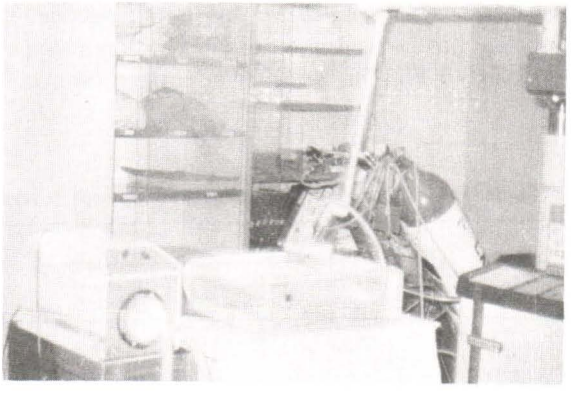

Fig. 3. Carbon dioxide laser with handpiece on the right ; plastic box with specimen for laser evaporation with nasal model connected to the lung model machine at the center; laser plume evacuator on the left.

tion in each filter were counted under a 10X40 optical microscope with each field area of 0.0013 cm^2. Each filter had an active filtration area of 0.9507 cm^2. Each Whatman filter and filter of the intranasal stent had 5 and 10 focal levels respectively.

RESULT

The efficacy of the intranasal stent with filters for 5, 10 and 20 shots of laser smoke particles was 90.5, 94.6 and 95.6 per cent respectively when compared with that of the Whatman filter (Table 1). The mean filtration efficacy of the intranasal stent with filters for all three shots of laser smoke particle was 93.6 per cent. Total particle amount in each filter was multiplied by ten fields particle count with 73.1308. The Whatman filter had the maximum laser smoke particle amount from the laser evaporative field of 4.3, 11.1 and 21.3 particles / cm^3 (Table 1). The laser smoke particle amount that passed through the Whatman or filters of the intranasal stent was the same. The mean particle amount in the Whatman filter was used to calculate the filtration efficacy of the intranasal stent with filters.

DISCUSSION

The suspended particulate matter amount in some parts of Bangkok is 3-4 times above the standard level of 0.33 mg/l[9,10]. The polydisperse particles amount from laser smoke matched that of suspended particulate matter in highly air-polluted areas[11-14]. The intranasal stent with filters as a personal respiratory protective device for suspended particulate matter prevention has not been reported previously[15-17]. The selection of a three layered filter depended on the nasal air flow resistance through the intranasal stent with filters in human nasal vestibules that was tested by standard anterior rhinomanometry[18].

More rigid filter material should be tried with an intranasal stent with disposible, easier for self-application, cheap and safety properties. Some particles in the filters of an intranasal stent are lost during the expiratory phase of the lung model machine and while preparing the filters for microscopic examination. The Whatman filter is more rigid than the filters of the intranasal stent. Laser smoke particles in the Whatman filter were the reference maximum value that passed through the filters of the intranasal stent. The cyclical air flow through the filters of the intranasal stent in the nasal model with the lung model machine mimicked the human respiratory system. The cyclical air flow rate of 2 l/min is equal to the continuous air flow rate of 7 l/min[19]. If the device could get rid of laser smoke particles effectively, it could also filter atmospheric suspended particulate matter. The higher particle amount creates more particle deposition in the filter material, increasing filtration efficacy and air flow resistance[20-22]. Sophisticated instruments such as the automatic particle counter under optical microscopy or the portable airborne particle counter under isokinetic conditions should be used.

SUMMARY

An intranasal stent with three layers of a half face mask outer filters was used to get various concentrations of laser smoke particles with the mean filtration efficacy of 93.6 per cent. Laser smoke particles are a suitable source for polydis-

Table 1. Efficacy of intranasal stent with filters for 5, 10 and 20 shots of laser smoke particles.

	laser smoke particle count * in filters at different shots					
	5		10		20	
	Whatman	filter**	Whatman	filter	Whatman	filter
Mean	580.6	525.4	1514.3	1432.2	2914.0	2785.8
+/-S.D.	44.8	78.9	123.0	194.7	273.8	455.3
Particles/cm^3 ***	4.3	-	11.1	-	21.3	-
Efficacy (%)****	-	90.5	-	94.6	-	95.6

* count in ten fields of each filter under 10x40 optical microscope

** three layer filters of intranasal stent

*** multiplied ten fields count in Whatman filter with 70.1308 to get total amount in 10 lilter of air flow

**** efficacy of intranasal stent with filters compared with Whatman filter

perse atmospheric suspended particulate matter. The cyclical air flow rates passed through the nasal model and the lung model machine mimicked the human respiratory system. The personal respiratory protective device was proposed for adult human nasal vestibules application in highly air-polluted areas. Selection of filter materials depended on maximum filtration efficacy, acceptable nasal air flow resistance, cost-effectiveness and human safety.

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ประสิทธิภาพของเครื่องถ่างช่องจมูกพร้อมแผ่นกรองอากาศต่อฝุ่นที่เกิดจากการเผาไหม้ของเลเซอร์ปริมาณต่าง ๆ กัน

*ครรชิตเทพ ตั้นเผ่าพงษ์, พ.บ.**

การทดสอบประสิทธิภาพของแผ่นกรองสองชั้นนอกจากชนิดที่ใช้ป้องกันฝุ่นหรือใช้ในห้องผ่าตัดสำหรับปิดปากและจมูก ซึ่งติด 2 แผ่นที่ปลายข้างหนึ่งและ 1 แผ่นที่ปลายอีกข้างหนึ่งของเครื่องถ่างจมูกที่เป็นท่อซิลิโคนกลวง สำหรับป้องกันฝุ่นปริมาณแตกต่างกันจากการเผาไหม้ของคาร์บอนไดอ็อกไซด์เลเซอร์ชนิด single mode เพื่อใช้แทนอนุภาคมลพิษซึ่งมีลักษณะใกล้เคียงกัน เทียบกับแผ่นกรอง Whatman ณ ภาควิชาโสต นาสิก ลาริงซ์วิทยา คณะแพทยศาสตร์ โรงพยาบาลรามาธิบดี ระหว่างเดือนกรกฎาคมถึงกันยายน พ.ศ.2541 โดยจัดให้มีปริมาตรการไหลของอากาศจำนวน 2 ลิตรต่อนาทีผ่านหุ่นจำลองคล้ายช่องจมูกด้วยเครื่องจำลองปอดเทียม จากการตรวจนับปริมาณฝุ่นบนแผ่นกรองด้วยกล้องจุลทรรศน์กำลังขยายสูงพบว่า แผ่นกรอง Whatman เก็บกักฝุ่นปริมาณสูงสุดซึ่งใกล้เคียงกับปริมาณฝุ่นจากแหล่งกำเนิด ประสิทธิภาพการกรองของแผ่นกรองในเครื่องถ่างช่องจมูก เมื่อมีฝุ่นจากการเผาไหม้ของเลเซอร์จำนวน 5, 10 และ 20 ครั้ง เท่ากับร้อยละ 90.5, 94.6 และ 95.6 ของแผ่นกรอง Whatman ตามลำดับ โดยมีค่าเฉลี่ยเท่ากับร้อยละ 93.6 จากข้อมูลดังกล่าวข้างต้นอาจนำเครื่องถ่างจมูกที่ประดิษฐ์ขึ้นใหม่นี้มาประยุกต์ใช้ในการป้องกันมลพิษในอากาศให้กับประชาชนคนไทย ทั้งนี้ผู้ใช้จะต้องใส่เครื่องมือชนิดนี้ในช่องจมูกส่วน vestibule

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

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