The Ramathibodi Nasal Filter in a Simulated Human Airway : Evaluated with Laser Smoke Particles and a Laser Diode Dust Portable Monitor

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Abstract

The Ramathibodi nasal filter was specially designed as a personal respiratory protective device. It was attached to a simulated human airway composed of a nasal and pharyngeal model, airway passage and lung model machine. The system was run in a laser smoke particles environment. The laser smoke particles with suspended particulate matter size of less than 15, 10 and 2.5 microns (PM15, PM10 and PM2.5) were selected. The amount of each particle size in the simulated human airway with and without the Ramathibodi nasal filter was measured continuously by a laser diode portable dust monitor. One hundred sample sizes were analyzed by a descriptive statistical method at the Department of Otolaryngology, Ramathibodi Hospital from January to November 1999. The graphic distribution patterns of each residual particle size in the simulated human airway with and without the Ramathibodi nasal filter were compared. The filtration efficacy of the Ramathibodi nasal filter should be tested further by this experimental model. The device could be applied intermittently in adult nasal vestibules.

Key word : Nasal, Filter, Simulated, Human, Airway, Laser Smoke Particle, Dust Monitor, Portable, Laser Diode

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The Ramathibodi nasal filter applied in a simulated human airway was proposed to be used in adult human nasal vestibules(1). The simulated human airway mimicked the human respiratory system composed of a nasal and pharyngeal model, airway passage and lung model machine(2). The filter got rid of laser smoke particles which caused injury to human health(3). The development of air

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pollution standards ideally involves the integration of data from the disciplines of epidemiology, controlled clinical studies, and animal toxicology. Laser smoke particles were used to represent suspended particulate matter. PM15, PM10 and PM2.5 were selected[4,5]. A laser diode portable dust monitor was the real time instrument which measured both amount and size of the particles[6]. The portable dust counter was used to detect the residual amount of laser smoke particles in the simulated human airway with and without the Ramathibodi nasal filter. The distribution patterns of the suspended particulate matter in the simulated human airway with and without the Ramathibodi nasal filter were analysed and compared.

MATERIAL AND METHOD

The Ramathibodi nasal filters are composed of a cylindrical medical grade silicone stent first with filter material sealed at both ends and second with filter material put inside. The simulated human airway was composed of a nasal and pharyngeal model, airway passage and lung model machine. The nasal and pharyngeal model was Y-shaped plastic with one circular outlet and two circular inlets. The inlets had a diameter like that of adult human nasal vestibules with the Ramathibodi nasal filter fitted at both ends (Fig. 1). The nasal and pharyngeal model outlet was connected to lung model machine inlet (Ventilog 2, Oranger, Germany) with the airway passage of a corrugated tube 3 cm in diameter and 60 cm in length by an adaptor. The experiment was conducted in the Department of Otolaryngology, Ramathibodi Hospital from January to November 1999. The lung model machine created a respiratory rate of 15 /min, tidal volume of 700 ml, inspiratory to expiratory phase ratio of 1:2 and was run for 1 minute for each test (Fig. 2). Laser smoke particles came from the same power of laser evaporation (Model 1060, Sharplan, Laser Industies Ltd., Tel Aviv, Israel) of a specimen put within a sealed plastic box. The box had one hole for the laser hand piece and two holes for the inlets of the nasal and pharyngeal model. The residual laser smoke particles in the simulated human airway after each Ventilog manipulation were measured continuously by a laser diode portable dust monitor (Series 1.104, Grimm Technologies Inc., Ainring, Germany) for 1 minute by an adaptor. Laser plume evacuator (X-plume, Sharplan, model 100, Laser Industries Ltd., Tel Aviv, Israel) cleaned the remaining laser smoke particles in the simulated human airway prior to next dust measurement (Fig. 3). One hundred samples size were calculated by a descriptive statistical method and the

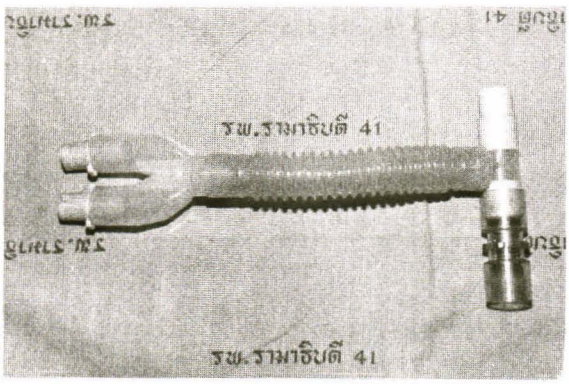

Fig. 1. The Ramathibodi nasal filter at both inlets ends of nasal and pharyngeal model on the left, adaptor with airway passage in the center or with the laser diode portable dust monitor on the right.

Fig. 2. Lung model machine in the center, airway passage with a box for laser evaporation on the right, laser diode portable dust monitor with adaptor and accessory on the left.

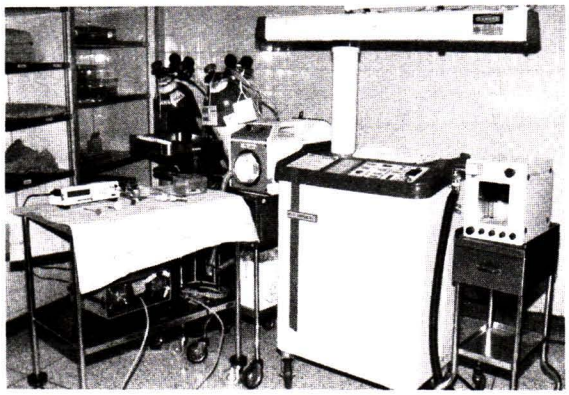

Fig. 3. Laser smoke particle generator and laser plume evacuator at the center, lung model machine on the right, laser diode portable dust monitor, adaptors and connecters on the left.

distribution patterns of residual PM15, PM10 and PM2.5 in the simulated human airway with and without the Ramathibodi nasal filter were shown.

RESULTS

Without the Ramathibodi nasal filter, the residual amount of laser smoke particles in the simulated human airway were continuously counted by a laser diode portable dust monitor. The suspended particulate matter of PM15, PM10 and PM2.5 amount were calculated by a descriptive statistical method. The mode and median of each particle size were not much different. The arithmetic mean of each particle size was higher than the mode and median value. The coefficient of variation of PM15 was 2.3 per cent which was less than 10.3 per cent and 12.6 per cent of PM10 and PM2.5 respectively. Third quartile (Q_3) and first quartile (Q_1) for PM15 were 44.9 and 37.5 with a quartile deviation of 3.7. Q_3 and Q_1 for PM10 were 38.6 and 32.4 with a quartile deviation of 3.1. Q_3 and Q_1 for PM2.5 were 34.1 and 27.9 with a quartile deviation of 3.1. (Table 1)

With the Ramathibodi nasal filter, the residual amount of laser smoke particles in the simulated human airway with mode, median and arithmetic mean of each particle size were not different. The coefficient of variation of PM15 was 17.0 per cent which was greater than 1.9 per cent and 5.5 per cent of PM10 and PM2.5 respectively. Third quartile (Q_3) and first quartile (Q_1) for PM15 were 54.7 and 44.7 with a quartile deviation of 5.0. Q_3 and Q_1 for PM10 were 44.5 and 39.5 with a quartile deviation of 2.4. Q_3 and Q_1 for PM2.5 were 40.4 and 32.9 with a quartile deviation of 3.8 (Table 2). The distribution patterns of residual of three particle sizes was very mildly skewed to the right and the graphic patterns of each particle size differed slightly from the others (Fig. 4 & 5).

DISCUSSION

The Ramathibodi nasal filter in a simulated human airway was proposed to testify retention of

Table 1. Descriptive statistics of continuous measurement of residual PM15, PM10 and PM2.5 amount in a simulated human airway without the Ramathibodi nasal filter.

	PM15 *	PM10 *	PM2.5 *
Mean ± SD	55.6 ± 1.3	45.5 ± 4.7	39.8 ± 5.0
Range	28 - 65	21 - 54	17 - 45
Mode	40	38	30
Median	41.2	35.5	31.0
CV **	2.3	10.3	12.6
QD ***	3.7	3.1	3.1

* Laser smoke particles with particulate matter size of less than 15, 10 and 2.5 microns

** The coefficient of variation (CV) in %

*** Quartile deviation (QD) = Q_3 minus Q_1 divided by 2

Table 2. Descriptive statistics for continuous measurement of PM15, PM10 and PM2.5 residual amount in a simulated human airway with the Ramathibodi nasal filter.

	PM15 *	PM10 *	PM2.5 *
Mean ± SD	49.4 ± 8.4	42.1 ± 0.8	38.5 ± 2.1
Range	30 - 71	27 - 56	26 - 42
Mode	50	45	39
Median	49.7	42.1	36.6
CV **	17.0	1.9	5.5
QD ***	5.0	2.4	3.8

* Laser smoke particles with particulate matter size of less than 15,10 and 2.5 microns

** The coefficient of variation (CV) in %

*** Quartile deviation (QD) = Q_3 minus Q_1 divided by 2

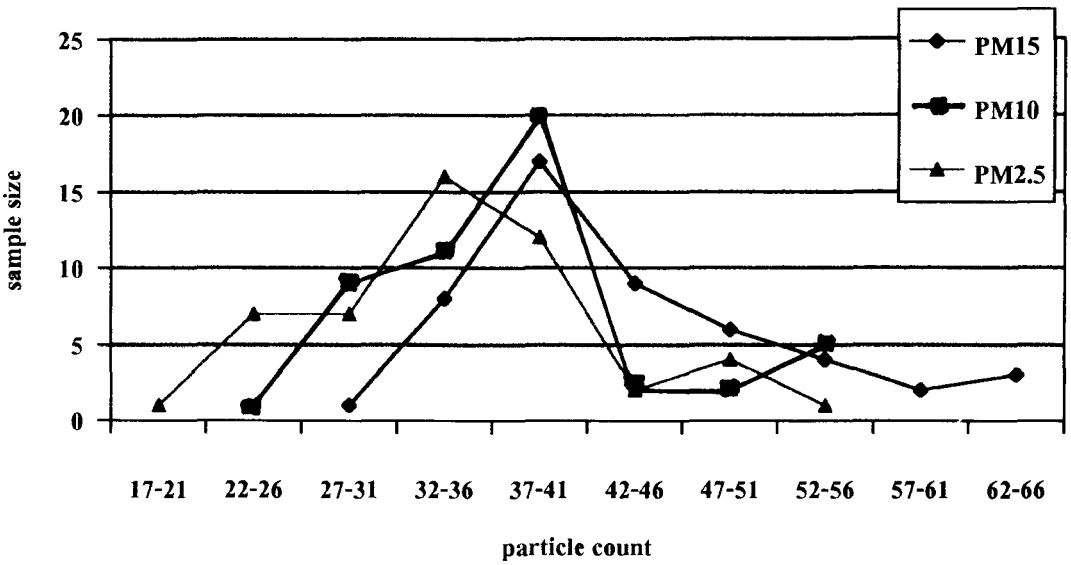

Fig. 4. Graphic pattern of residual PM15, PM10 and PM2.5 distribution in the simulated human airway without the Ramathibodi nasal filter.

suspended particulate matter in the human respiratory system. It is a specially designed personal respiratory protective device[7]. The simulated human airway with the Ramathibodi nasal filter testified the impact of air pollution on human health[8]. Laser smoke particles were used as a source of suspended particulate matter as in our previous study[9]. Laser smoke particles less than 15, 10 and 2.5 microns were selected due to their human health impactions. Air particles with a diameter of less than 10 microns are a threat to public health but tiny particles with a diameter of less than 2.5 microns are more dangerous[10]. The dust measurement ranges include occupational and environmental situations. The occupational values was inhalable, thoracic and respirable dust and U.S. Environmental Protection

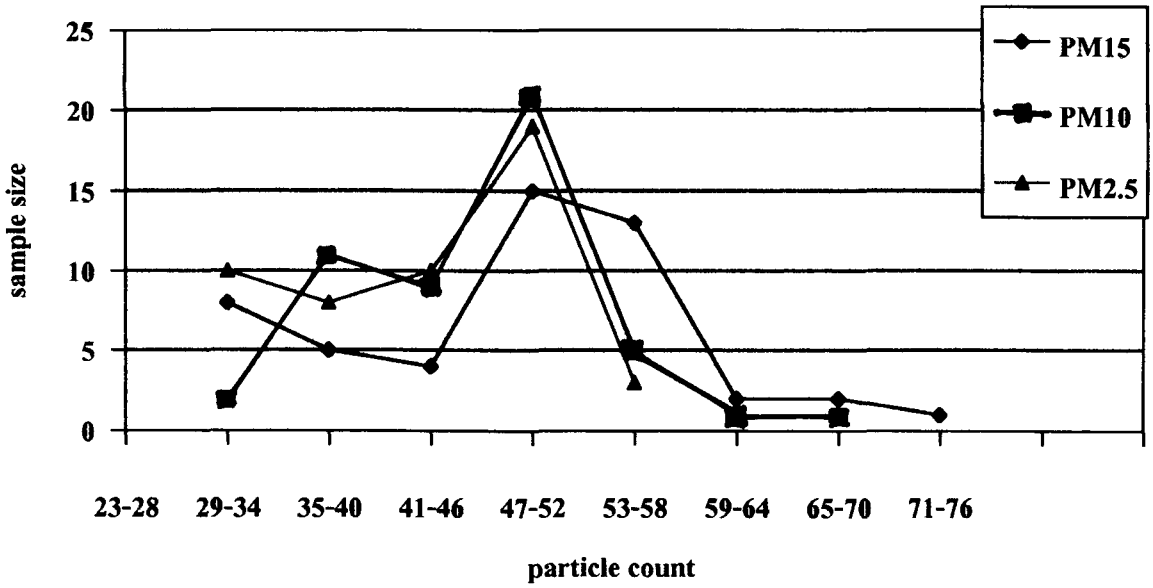

Fig. 5. Graphic pattern of residual PM15, PM10 and PM2.5 amount distribution in the simulated human airway with the Ramathibodi nasal filter.

Agency (EPA) criterias include PM15, PM10 and PM2.5[11,12]. A laser diode portable dust monitor measured continuously the residual laser smoke particles in the simulated human airway with and without the Ramathibodi nasal filter. Epidemiological studies showed statistical associations between health outcomes and exposure; they could not establish a definite cause-effect relationship[13]. The utility of toxicological studies is to establish this relationship[14]. An almost symmetrical distribution pattern of PM15, PM10 and PM2.5 amount in the simulated human airway with and without the Ramathibodi nasal filter were shown. This experimental model could be used further for evaluation of efficacy of the Ramathibodi nasal filter applied in human nasal vestibules.

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วัสดุกรองชนิดรามาธิบดีสำหรับใส่ในช่องจมูกประเมินด้วยเครื่องเลียนแบบทางเดินหายใจมนุษย์ภายใต้สภาวะฝุ่นเผาไหม้จากเลเซอร์และเครื่องตรวจนับฝุ่นซึ่งหิ้วได้ชนิดเลเซอร์ไดโอด

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การทดลองใส่วัสดุกรองในมนุษย์ต้องอาศัยผลการทดลองในห้องปฏิบัติการ ผู้ทดลองนำวัสดุกรองชนิดรามาธิบดีสำหรับใส่ในช่องจมูกนำไปสอดใส่ในเครื่องเลียนแบบทางเดินหายใจของมนุษย์ ซึ่งประกอบด้วยหุ่นจำลองช่องจมูกและลำคอ ช่องทางเดินหายใจและเครื่องทำงานแทนปอดในสภาวะฝุ่นที่เกิดจากการเผาไหม้ของเลเซอร์ โดยกำหนดขนาดของฝุ่นที่เล็กกว่า 15, 10 และ 2.5 ไมครอน (PM15, PM10 and PM2.5) ซึ่งตรวจวัดอย่างต่อเนื่องของฝุ่นแต่ละขนาดด้วยเครื่องตรวจนับฝุ่นซึ่งหิ้วได้ชนิดเลเซอร์ไดโอด ทดลองด้วยจำนวน 100 ตัวอย่าง ณ ภาควิชาโสต นาสิก ลาริงซ์วิทยา คณะแพทยศาสตร์ โรงพยาบาลรามาธิบดี ระหว่างเดือนมกราคมถึงเดือนพฤศจิกายน พ.ศ. 2542 การใช้สถิติเชิงพรรณาสำหรับการคำนวณค่ากราฟแสดงการกระจายของข้อมูลเพื่อเปรียบเทียบสำหรับฝุ่นแต่ละขนาดภายในเครื่องเลียนแบบทางเดินหายใจของมนุษย์ขณะที่ไม่มีและขณะที่มีวัสดุกรองในช่องจมูกชนิดรามาธิบดี การทดลองนี้ทำให้ทราบรูปแบบการกระจายของฝุ่นภายในเครื่องเลียนแบบทางเดินหายใจของมนุษย์ การประยุกต์เพื่อหาประสิทธิภาพของวัสดุกรองชนิดนี้เพื่อป้องกันสุขภาพของมนุษย์จากมลภาวะทางอากาศเป็นเรื่องที่กำลังทำการศึกษาต่อไป

คำสำคัญ : วัสดุกรอง, ช่องจมูก, เลียนแบบ, ทางเดินหายใจ, มนุษย์, ฝุ่นเลเซอร์, เครื่องตรวจนับฝุ่นซึ่งหิ้วได้, เลเซอร์ไดโอด

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