Epidemiology of Environmental Tobacco Smoke

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The chemical composition of SS, MS and US (used smoke originating in MS exhaled in the air) are similar. However, significant quantitative differences exist among these sources. Although nicotine is unique to ETS, it cannot trace a change at interval of a minute. We succeeded in monitoring the trends of ETS in the cabin of an aircraft with a combination of nicotine and SPM. Urinary cotinine and/or the self-reported method according to Jarvis's categories are generally used to estimate exposure to ETS. We maintain with examples that the urinary HOP ratio is also useful for this purpose. Epidemiological studies on ETS unavoidably involve various biases in measurement of ETS, such as the epidemiological step. Meta-analysis and so forth. For example, because the relative risk of ETS for lung cancer should be so far than that of smoking, such a bias may lead a final conclusion astray.

ETS (environmental tobacco smoke), Nicotine, Cotinine, HOP ratio (hydroxyproline to creatinine ratio), Meta-analysis

INTRODUCTION

ETS is a third type of tobacco smoke, ranking along with mainstream and sidestream smoke. ETS is a diverse and active mixture consisting of several thousand constituents, some of which may act as useful surrogates for ETS. However, accurate detection of these surrogates is often difficult, because many of them are present in extremely low concentrations in the air. Further, many substances emigrating from other indoor sources are found in ETS. Thus, it is difficult to trace the existence of substances originating in ETS. Moreover, the diverse physical and chemical characteristics of ETS are built up with changes over brief periods of time. This quality of ETS, therefore, makes the measurement of exposure to ETS complicated. As a result of this complexity, there is no generally accepted and standardized method for its quantitative analysis. ETS consists of sidestream smoke (SS) generated by the burning cigarette and used smoke (US), which is mainstream smoke (MS) exhaled by the smoker. The chemical compositions of sidestream and used smoke are similar. However, significant quantitative differences exist among these three sources. Because SS is generated by a low-temperature burning cigarette, the concentration of each constituent is higher than for MS. Also, as much of the constituents of MS is absorbed in the upper and under airways during the process of
inhalation and exhalation, the concentration of each constituent in the used smoke is decreased. For this reason, if SS is used as a representative of ETS, the ill effects of ETS may be overestimated. ETS occurs only in indoor environments, and the concentration of ETS is controlled by the volume and ventilation rate in the room; moreover, SS and US ages rapidly in indoor environments: for example, 90% of nicotine in SS and US translate from particulate phase to vapor phase in ETS. In any case, active smoking and passive smoking are very similar in appearance but quite different in quantitative nature, and not only nonsmokers but also smokers are exposed to ETS.

ETS IN THE CABINS OF COMMERCIAL AIRCRAFT

Measurement of ETS (environmental tobacco smoke) is practiced with different technique for indoor environments and for bodily fluids such as blood, urine and saliva, using different suitable markers and technique.

However, the author process a new technique using SPM (suspended particulate matter) in commercial aircraft\(^1\). As the cabin is a perfect airtight chamber, outside nicotine or SPM cannot enter the cabin. Therefore, these pollutants originate from passenger's smoking, except for some contained in recirculated used air. If nicotine or SPM is found in the no-smoking zone, it seems to be due to recirculated used air or to escape of ETS from the smoking zone.

SPM in the cabin is measured with a direct reading instrument that records once every one minute during flying time. At the same time, nicotine is measured using a time-integrated method, with one sampling taken in series. The author traced ETS in the cabin of a commercial Boeing 747 air line twelve times. After adjusting the temperature, compressed fresh air is distributed by a pneumatic system to each zone. The used air is discharged from the outflow valve, but a portion of the used air is sent up recirculation. The ventilation rate is adjusted with in steps from 4 to 13 minutes per exchanging used air for fresh. This fast ventilation rate interrupts the movement of ETS from this smoking zone to nonsmoking zone. Because a real-time analysis of ETS in connection with smoking was necessary, the direct reading instrument for SPM was applied. At the same time, a time-integrated technique was used for nicotine with one sample taken in series. A short peak of SPM appeared in connection with smoking (Fig. 1), for example, just after turning off the no smoking sign, and after meals and refreshments. These peaks also diminished with no smoking sign at once and during movie hours and sleeping time. However, in the case of nicotine, it was impossible to confirm a close connection with smoking every minute, because a direct reading instrument for measurement of nicotine had not yet been developed. According to the current established opinion, it has been said that SPM cannot act for nicotine in the ETS, because 90% of the nicotine in ETS exists in the vapor phase. However, SPM may be an indicator of the ETS related to smoking, although it is limited in special occasions. Cumulative nicotine concentrations measured in series for the nonsmoking zones were also significantly lower than those for the smoking zone. SPM of some non-smoking areas of the economy class in a certain Flight, exceptionally, exceeded the level allowed by the control low for the buildings in Japan, when many passengers smoked all at once, or unusual smoking happened.

Muramatsu, M.\(^2\) also measured changes in the concentration of ambient cotinine and SPM with the passage of time in an office (in the presence of some smokers?) (Fig. 2). One nicotine monitor was used every thirty minutes for 10 hours. The nicotine concentrations in the office corresponded to the rise and fall of SPM concentrations and the number of cigarettes smoked. This fact argues for the truth of the author's view.
URINARY COTININE AND HOP RATIO

The urinary cotinine concentration in nonsmokers has been widely used as a better surrogate because its half-life time is relatively longer than that of nicotine. On the assumption that the half-life time of cotinine is 20 hours and the time-lag between exposure to ETS and collection
of the urine sample is also 20 hours, the cotinine level of the sample is reduced to half of the level just after exposure to ETS. On the other hand, a new method was developed by Jarvis et al. (3). The reported a strong relationship between self-reported exposure to ETS and urinary cotinine level. Each self-reported exposure level was classified based on the following categories: “yes, a lot,” “yes, some,” “yes, a little” and “not at all”, for several days, Riboli, Shimizu et al. (4) reported in their 10-country collaborative study in 1990 that the interpretation of epidemiologic studies of ETS depends largely on the validity of self-reported exposure. Exactly, this study shows that Jarvis’s method can overcome the time-lag bias related to urinary cotinine. However it may be difficult to assume a relationship between ETS and chronic health effects (for example, lung cancer), even if exposure level to ETS within several days is estimated.

Accordingly, the current research team searched for a new biological marker for health effects caused by smoking and ETS. HOP ratio (hydroxyproline to creatinine ratio) (5), which indicates chronic breakdown of lung collagen and it is not necessary to take time-lag bias into consideration in theory. The mean value of the HOP ratio in schoolchildren is almost 100.0, and about 20.0 in adults. The study team was given an opportunity to try a double-blind test to compare the HOP ratio and cotinine in 107 urine samples, from nonsmoking women. The controller sent the same urine samples to laboratories A and B, with no additional detailed information. Laboratory A was in charge of the HOP ratio, and laboratory B was responsible for the cotinine concentration. According to the report from the controller, the correlation coefficient between the two values was 0.816 (Fig. 3). Therefore, the usefulness of the HOP ratio is almost the same as for cotinine. The next study suggested that the urinary HOP ratio is useful as a biological marker for short-term breakdown of lung collagen and lung elastin as follows (8): the effects of abstinence from smoking on the HOP ratio was assessed in 49 smokers participating in a stop-smoking project. Urine samples were collected at the beginning of the course and over the following 14 weeks (Fig. 4). The subjects were divided into five groups depending on the number of cigarettes smoked daily before abstinence: 1–10, 11–20, 21–30, 31–40 and > 40 cigarettes. The urinary HOP ratio immediately after abstinence from smoking was proportional to the mean daily number of cigarettes smoked in the past. All groups showed decreasing HOP ratios with a longer period of abstinence. Half of the total decrease observed in the HOP ratios after 14 weeks was reached within five or six weeks. When using the Brinkman index to adjust for the number of smoking years, half of the maximum decrease in all groups was reached within four weeks. In an exponential decay model fitted to the data, the half-life time taken to reach the non-smokers’s level was nine to ten weeks for all groups. The HOP level of smokers who smoked less than 41 cigarettes before cessation approached the HOP level of the control group after 61-74 weeks.
Figure 3  Correlation between urinary HOP ratio and cotinine.

Figure 4  Evaluation on the abstinence from smoking with HOP-ratio by Brinkman Index. Urine of non-smokers could not be collected after 2, 6 and 12 weeks.
ETS AND LUNG CANCER

The relationship between exposure to ETS and lung cancer was advocated by Hirayama (Japan) and Trichopoulos (Greece) in 1981. Especially, Hirayama’s work has been highly evaluated because it was performed with data from his cohort study including 270,000 adults aged 40 and above who were followed up for 17 years (1966–82). Since his model was planned in 1965 when the concept of ETS exposure was not established, asking him for epidemiological accuracy of today is far from fair. However, this study draws a conclusion from the promise that smoking habits in 1965 were constant during the follow up period (1966–81). Generally speaking, smoking habits are very changeable with lapse of time and it may affect an interpretation of relationship between ETS and lung cancer. Therefore, this study should have checked smoking habits like Framingham study where smoking habits survey has been repeated once two years and classification of subjects by smoking habits was rearranged whenever such a survey was done.

Case-control study set up in the area where cancer registration system is established may be useful for this sort of study rather than cohort study, so far as biases related to the control group is suppressed. According to the several case-control studies reported in the last five years carried out in some regions with high mortality rates of lung cancer and low smoking rates, indoor air pollutants as various smoke from burning of wood, straw, cooking oil, incense and so on closely related to lung cancer.

In 1986 NAS (USA) reported the combined relative risk was 1.34 (significant) by meta-analysis using 13 among 23 papers. However, this risk may be reversed to insignificant if negative reports by Shimizu (1988), Wu-Williams (1990), and Sobue (1990) are added to 13 reports used by NAS study.