Original Article

Concept of BIDI years: Relevance to the perioperative period

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ABSTRACT

Background: The cumulative effect of cigarette smoking is usually measured by "pack years," but the same is not present for Bidis. This study was conducted to calculate the concept of "bidi years" in comparison to the concept of "pack-years" for a cigarette. **Methods:** Thirty random samples, each of bidis and cigarettes, were selected through a survey of common brands used by smokers in India. The nicotine and carbon monoxide (CO) contents were analyzed by high-pressure liquid chromatography and gas chromatography methods, respectively. **Results:** The average nicotine content in thirty samples of different Bidis and Cigarettes was 214.46 ± 57.8 and 616.31 ± 22.6 mg/dL, respectively ($P < 0.001$). The CO content with a lower mean of 15.57 ± 5.88 was observed in cigarettes as compared to 70.4 ± 22.08 in bidies ($P < 0.001$). The weight of one cigarette is 0.56 times that of the weight of one bidi. Based on the nicotine content, the equivalent pack years for bidis is calculated as 43 bidis per day per year. **Conclusion:** Based on the nicotine content, it is proposed that the equivalent for one cigarette pack-year or 20 cigarette years are taken as 43 bidis per day per year. Even though each bidi stick has an average of 0.46 times the nicotine content of cigarettes, longer abstinence as compared to cigarette is required to bring the nicotine level to normal due to the deeper puffs needed. With the CO content of bidis being 4.5 times that of cigarettes, it is advised that the minimum duration of cessation of smoking before operative procedures be 24 h as compared to 6 h for cigarettes.

KEY WORDS: Bidi, carbon monoxide, cigarette, nicotine, pack year

INTRODUCTION

Tobacco smoke is a complex mixture of differently sized particulate matter (PM), suspended volatile and semi-volatile compounds, and combustion gases.[1,2] These compounds are associated with the well-documented cardiopulmonary complications in smokers which increase the perioperative morbidity. The risks increase exponentially with a given cumulative dose, and the duration of exposure to smoking. It is generally accepted that some adverse cardiopulmonary effects induced by nicotine and carbon monoxide (CO) among the compounds are reversible with cessation of smoking.[3,4] However, the optimal timing of preoperative smoking cessation is an important clinical question.[5]

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An acceptable tool to quantify the exposure of an individual to cigarette smoke is the concept of "pack-years." However, it is difficult to rely on this assessment as there are different types of tobacco leaves with varying degrees of processing and so varying amounts of nicotine as well as a different number of cigarettes per pack by different companies in the market.[6,7]

In India, an estimated 108 million males and 11 million women between 15 and 69 years of age have been smoking tobacco in any form in 2015. Among the total consumption of smoked tobacco, 73% is in the form of bidis and 27% is in the form of cigarettes.[8] Bidis have less tobacco than regular cigarettes, but being unfiltered, it is generally considered that these deliver 3-5 times more nicotine and other harmful substances such as tar and CO than regular cigarettes. Moreover, because they are thinner than regular cigarettes, they require about 3 times as many puffs per cigarette.[8,9]

Hence, the need to quantify the exposure to bidi smoke for assessing perioperative morbidity is felt. The primary outcome of this study was to determine the nicotine and CO content of bidis and compare these with cigarettes. This will be used to elaborate a concept of "Bidi pack-years" and its equivalence to cigarette pack-years. The question "How many packets of bidis or bidis are you smoking per day and for how long?" Will be proposed to be included in the preoperative questionnaire. Based on the nicotine content of bidis and considering the half-life of carboxyhemoglobin to be 4–6 h, an analysis of time for abstinence of smoking bidis before surgery was also done as a secondary outcome.

MATERIALS AND METHODS

This was an observational study, in which two groups were made, Group B consisting of 30 random samples of commonly used brands of bidis and Group C consisting of 30 random samples of commonly used brands of cigarettes, both Indian and foreign obtained from local retail outlets for the study. The brands were identified from a survey conducted among retailers selling cigarettes and bidis in selected cities/towns/villages from various parts of the country. Tobacco weights of the cigarettes and bidis were based on an average of thirty cigarettes and bidis. There were no exclusion criteria. For each brand of cigarette and bidi, the tobacco was taken out from the wrapping, weighed, and burned out for chemical analysis. The nicotine and CO contents were analyzed by high-pressure liquid chromatography (HPLC) and gas chromatography (GC), respectively, by the Division of Radiopharmacy and Cyclotron at the Institute of Nuclear Medicine and Allied Sciences under the aegis of Defense Research and Development Organization.

Nicotine analysis
Nicotine content was analyzed by a reversed-phase HPLC. After the HPLC column (reverse phase C18 Waters Atlantis Dimensions: 4.6 mm × 250 mm; 5 µ) was

calibrated, absorbance Maxima at 210nM was determined by Ultraviolet spectroscopy of known standard and accordingly set to 210nM. The flow rate of the mobile phase was set to 1.000 mL/min which enabled all components to elute ensuring resolution of individual peaks. The minimum and maximum pressures on the solvent delivery system were verified. The mobile phase was prepared by adding 600 mL of methanol to 400 mL of purified deionized water (60:40). The mobile phase was filtered through a 0.47-µm membrane filter under a vacuum to degas the solution. A standard nicotine calibration curve based on Area under curve was obtained. The *r* value meets the linearity requirements for a valid analysis method = 0.993. Based on the calculation results of the linear line equation, the correlation coefficient (*r*) of 0.993 is obtained with the straight-line equation Y = 31069x + 275.63 [Figure 1a]. The test solution consisted of 50 mg of tobacco dissolved in 20 mL sodium hydroxide solution. After 15 min, the solution was filtered and mixed with 2-Grade water. The filtrate was neutralized with acetic acid and again filtered with a Nylon 0.20 microfilter. Twenty microliters were injected using mobile phase water: methanol (40:60) and run for 25 min for each sample.

Carbon monoxide analysis
This was done using a discharge ionization detector GC. Helium was passed through a chamber where a glow discharge is generated, and high-energy photons are produced. The high-energy photons were passed through an aperture to a second chamber and the CO was ionized in the sample stream. The resulting ions produced an electrical current, which was measured with a standard electrometer [Figure 1b].

Statistical analysis
Sample size was calculated using difference of means (+standard deviation) of nicotine between bidis 21.37 mg/g (±3.30) and cigarettes 15.01 mg/gm (±3.88).[10,11] With a confidence level of 99% and power of 90%, the calculated sample size was ten brands in each group. Three random cigarettes/bidis were taken in each brand making a total of thirty samples each in both groups. SPSS Statistics for Windows, version 23.0. 2015 (SPSS Inc., Chicago, Ill., USA) was used to perform the statistical analysis of the data. The mean nicotine and CO content of bidis and cigarettes were compared using an unpaired *t*-test. Before the unpaired *t*-test, the data were analyzed for homogeneity of variances (an assumption for performing unpaired *t*-test) using Levene's test. Mann–Whitney *U*-test was used for data with $P < 0.05$ for Levene's test. $P < 0.05$ was considered statistically significant.

RESULTS

The nicotine and CO content in 30 sticks of 10 common brands of bidis (Group B) compared with 30 sticks of 10 common brands of cigarettes (Group C). Both the

average tobacco contents per stick as well as nicotine content per stick were seen to be higher in Group C as compared to Group B [Table 1 and Figure 2]. The average nicotine content in ten different bidis brands in Group B was 214.46 ± 57.8 mg/dL, and the average nicotine content in ten different cigarette brands in Group C was 616.31 ± 22.6 mg/dL [Table 2 and Figure 2]. The average bidi nicotine content was seen to be 0.46 times ($P = 0.001$) than the average content of cigarettes. While the overall content of nicotine was higher in Group C as compared to Group B, there was a wider variation in nicotine content among bidis as compared to cigarettes.

Statistically significant differences were observed in average CO content between the two groups with a lower mean of 15.57 ± 5.88 ng/ml in Group C as compared to a mean of 70.4 ± 22.08 ng/ml in Group B. ($P = 0.001$) [Figure 3]. The CO content of thirty bidis was analyzed to be 4.52 times higher than all 30 cigarettes samples [70.4 ng/ml vs. 15.6 ng/ml; Table 2]. On Mann–Whitney *U*-test, there is a difference between the rank of two samples ($Z = -6.653$, $P < 0.05$).

The weight of one cigarette is 0.56 times that of the weight of one bidi [Table 1]. Based on the nicotine content of 20 cigarettes per day per year which is the definition of pack years for cigarettes, the equivalent pack years for bidis is calculated as 43 bidis per day per year [Table 3].

DISCUSSION

Tobacco smoke is a complex mixture of differently sized PM, suspended in over 4000 volatile and semi-volatile compounds and combustion gases (gas fraction; Gf).[1,2] The U. S. Environmental Protection Agency has classified PM as per size into coarse inhalable particles ≤10 µm (PM_{10}), fine inhalable particles ≤2.5 µm ($PM_{2.5}$), and ultrafine PM of size ≤1 µm (PM1).[12] The PM size reflects the level of penetration into the respiratory tract as well as the ability to adsorb toxic organic molecules affecting both short- and long-term effects of smoking.[13] Apart from nicotine and CO, many other compounds such as nitrogen oxides, volatile aldehydes, polyacrylic aromatic hydrocarbons, alkenes, and hydrogen cyanide are pharmacologically active, toxic, mutagenic, and/or carcinogenic.[14,15] Tobacco nicotine exists in both acidic and basic forms.
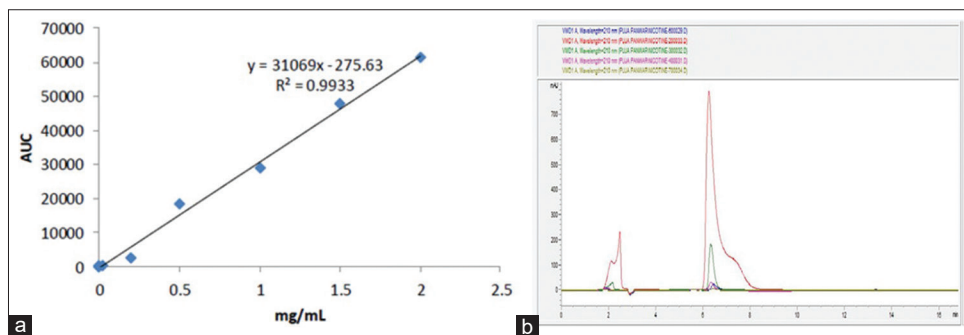
Figure 1: (a) Standard Nicotine calibration curves based on Area under curve was obtained. The r value meets the linearity requirements for a valid analysis method = 0.993. Based on the calculation results of the linear line equation, the correlation coefficient (*r*) of 0.993 is obtained with the straight line equation Y = 31069x + 275.63 (b) showing Carbon monoxide ions produced electric current which are measured with electrometer. #AUC: Area under curve, ROC: Receiver operator characteristic curve
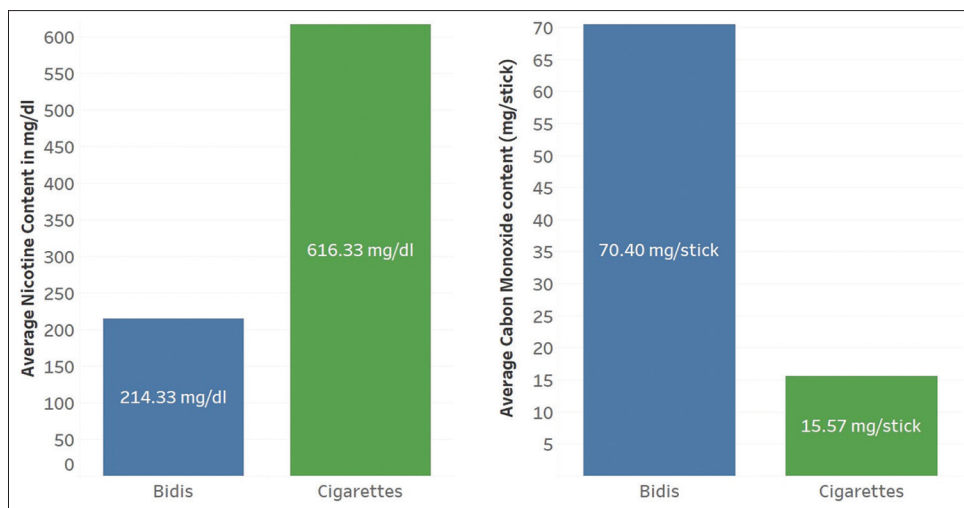
Figure 2: Comparison of the average Nicotine (mg/dl) and Carbon monoxide (mg/stick) content in Cigarettes and Bidis

Table 1: Average tobacco and nicotine contents in bidis and cigarettes

	Average weight/ stick (mg)	Tobacco content per stick (mg)	Percentage of tobacco/ stick	Nicotine content (mg per g of tobacco)
Bidi	365.9	187.7	51*	26.9
Cigarettes	826.4	721.2	87	14.8

*Weight of the tendu leaf, #Tobacco content/stick, *Nicotine content (mg/g)/average weight

Table 2: Group statistics of average nicotine and carbon monoxide content

|	Group	*n*	Mean	SD	SEM
Average nicotine content (mg)	B	30	214.4800	57.81838	10.37808
	C	30	616.3100	22.63133	13.48121
Variation	**Nicotine content of Group B is 34.8% of Group C**				
	Nicotine content of Group C is 2.87 times more than Group B				
Average carbon monoxide content (ng)	B	30	70.4000	22.08232	6.98304
	C	30	15.5700	5.88181	1.85999
Variation	**CO content of Group C is 22.1% of Group B**				
	CO content of Group B is 4.52 times more than Group C				

SD: Standard deviation, SEM: Standard error of mean

Table 3: Calculation of bidi years from nicotine content of cigarettes

	Nicotine content per stick (mg)	Nicotine content per stick in 1 pack years	Equivalent number of bidis in one pack year (with average nicotine content of 78840 mg)
Cigarettes	10.80	20 cigarettes×365 days×10.80 mg=78,840 mg nicotine	-
Bidi	5.04	-	78,840 365×5.04=43 bidis/day in one year

The protonated, acidic form clings to the PM from where nicotine is absorbed slowly wherever the PM deposits in the respiratory tract. Freebase form volatilizes in the Gf and is rapidly absorbed in the respiratory tract.[6,7,13-17]

Among the perioperative complications, smokers have demonstrated significantly greater odds for developing pneumonia, unplanned intubation, and mechanical ventilation due to mucous hypersecretion and airflow obstruction.[3-7,18,19] The ciliotoxins (Acrolein, formaldehyde, phenol, and potassium cyanide) present in tobacco smoke increase mucous production and weaken mucus clearance in the tracheabronchial tree. The resultant hyperviscous thick mucus secretion causes microatelectasis which forms the nidus for pneumonia. Increased airway reactivity due to smoke irritants predisposes the patient to frequent episodes of breath-holding, laryngeal spasm, bronchospasm, hypoventilation, and hypoxia during anesthesia induction and emergence. The smoke irritants also damage the lung
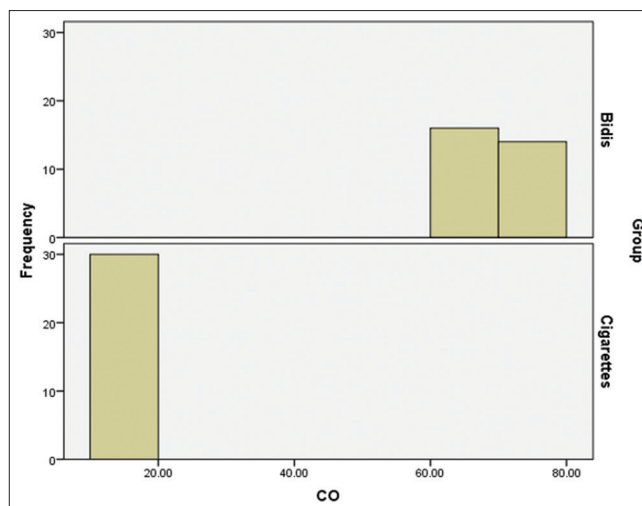
Figure 3: Histogram representing both groups frequency with (Carbon monoxide). X axis represent Carbon Monoxide content in both groups and Y axis represent frequency of both groups One-Sample Kolmogorov-Smirnov Test, Bidis and cigarettes group having mean of 70.40 ± 6.98 and 15.57 ± 1.85, 95% confidence interval (−57.46−−52.19)

epithelium with an increase in proteolytic and elastolytic enzymes.[20] This aggravates both chronic bronchitis and emphysema. Independently, these pathological changes lead to impaired gas exchange function.[3,17,19,20]

Smokers also are significantly more likely to experience a perioperative cardiac arrest, myocardial infarction, and stroke. Nicotine stimulates the sympathetic system with resultant increases in heart rate, blood pressure, contractility, and peripheral vascular resistance. This shifts the myocardial oxygen supply-demand ratio increasing the incidence of ischemic myocardial damage. The damage is further compounded by raised intracellular calcium, a response to nicotine stimulation. CO in tobacco smoke binds to hemoglobin leading to carboxyhemoglobin levels up to 7%–15%. There is a resultant shift of the oxygen dissociation curves to the left with reduced oxygen availability to tissues.[3,4,20-23]

Smoking is also a well-documented major risk factor for wound-related complications such as superficial and deep incisional infections, sepsis, and septic shock due to impairment of humoral activity and cell-mediated immunity and decrease in immunoglobulin and leucocyte activity.[3,23]

The various definitions of different subsets of smokers are given in Table 4.[24]

It has been estimated that 01 plain/filter cigarette and 1 g of pipe tobacco is equivalent to 1 g of tobacco, one cigar is equivalent to 5 g of tobacco, and one cheroot or cigarillo is equivalent to 3 g of tobacco. 2.5 g or half an ounce of loose tobacco was approximately equivalent to one packet of 20 cigarettes. Cigarette and loose tobacco contain a

"reconstituted tobacco" that was extracted from the tobacco scraps and shaped into curls.[9,15,25-27]

The tobacco rolled in bidis is different from that used in cigarettes and is referred to as bidi-tobacco. "Bidis" or "beedis" are small, hand-rolled unfiltered cigarettes containing tobacco flakes rolled in unprocessed tobacco, tendu, or temburi leaf and tied with thread.

Traditionally, bidi pack-years have been roughly estimated as 0.25–1 of cigarette pack-year.[26,27] Bidis available in the United States contain three to five times more nicotine than traditional cigarettes.[25] Bidi production in India is largely unregulated, with different bidi packs having variations in amount and content of fillings. Nicotine availability is also dependent on the curing process of the leaf in which the tobacco is rolled. Tobacco content, by weight, in bidis (150–250 mg) is one-fourth that of cigarettes. Also, the numbers of bidi stick present per pack are inconsistent, ranging from 20 to 25 bidis per pack. Additionally, it takes an average smoker about nine puffs to finish a regular cigarette, while it takes approximately 28 deeper puffs to finish a bidi. This is because bidis are unfiltered, the leaf is less combustible, and thinner than regular cigarettes; this increases the delivery of smoke, nicotine, and CO to the smoker.[14-16,25] Other studies have also confirmed that despite lower nicotine content per stick, the average serum nicotine concentration in bidi smokers at 30 min is significantly higher (260 ng/ml) than cigarette smokers (180 ng/ml).[25,27,28]

Pack years are calculated by multiplying the number of packs smoked per day by the number of years the person has smoked, taking an average of 20 cigarettes per pack. For example, 1 pack-year is equal to smoking 1 pack of 20 cigarettes per day for 1 year.[6,7]

In this study, we took 30 different sticks of cigarettes and bidis each from 10 each Indian and foreign brand. Since the number of bidis per pack differs as per the brand, it is therefore proposed that bidi pack-years should be renamed as "bidi-years." Collating the definition of pack years for cigarettes as per the nicotine content of 20 cigarettes per day per year, the equivalent pack years for bidis is 43 bidis per day per year.

The half-life of nicotine is 30–60 min, and abstinence of cigarette smoking for 12–14 h improves ciliary function and brings down the nicotine level to normal.[11,12,19] Even though each bidi stick has an average of 0.46 times the nicotine content of cigarettes, longer abstinence as compared to cigarettes is required to bring the nicotine level to normal. Abstinence of 8 weeks derives the maximum benefits of stopping cigarette smoking, and the same should be allowed for bidis too.

The factors that influence the CO yield of a given brand of cigarettes depend on the manufacturing process (for example, porosity of the paper and filter ventilation) and therefore may vary independently of tar yield. The absorption of CO is more dependent on the depth of inhalation than is the absorption of nicotine, and, if a change to lower tar products results in a compensatory increase in depth of inhalation, smoker exposure to CO may remain unchanged or increase compared to dosages from the higher tar brands.[19,24,27,28]

The average CO levels analyzed after combustion in this study were found to be 4.51 times higher than in cigarettes. This aligns with the higher average breath CO levels in patients smoking bidi for >5 years as compared to cigarette smokers (19 parts ppm and 13 ppm, respectively).[25,28] The half-life of carboxyhaemoglobin is 4–6 h at rest.[1,14,23,28] Hence, discontinuation of bidi smoking should be strongly advised at least 24 h preoperatively. In case that is not feasible, administering 100% oxygen in the preoperative period may significantly expedite the removal of CO as the strong affinity of CO for binding to hemoglobin (250 times more than that of oxygen) can be offset with a decrease in the half-life of CO to 40–80 min.[18,19,21]

Limitations of the study include a small sample size since the cost of analysis of both nicotine and CO is high. Moreover, plasma samples of nicotine and carboxyhaemoglobin were not analyzed after abstinence.

CONCLUSION

Since there is a statistically significant difference in the constituents, bidis and cigarettes are to be taken as different entities. In view of the variation in the number of bidis per pack, it is proposed that in order to quantify the exposure

Table 4: Definition of smokers

Smoker*: A person who smokes any tobacco products (entirely or partly made of the leaf tobacco as raw material)	Ever smokers#: A person who has smoked >100 cigarettes during their entire life	Light smoker$: A smoker who confessed consuming between 1 and 10 cigarettes per day Moderate smoker$: A smoker who confessed consuming between 11 and 19 cigarettes per day Heavy smoker$: A smoker who reports consuming 20 cigarettes or more per day	Current smoker#: A person who confesses to smoking part or all of a cigarette during the 30 days preceding the interview and consumed >100 cigarettes in his/her life time$ "Former smoker#" An ever-smoker who was not smoking at the time of the interview	Daily smoker# Occasional smoker#
	Never smokers#	A person who was neither smoking at the time of interview nor consumed 100 cigarettes in his/her life time		

*Smoking and tobacco use policy of the world health organization, #Centers for disease control and prevention, national center for health statistics, $National survey on drug use and health

of an individual to bidi smoke, the concept of "bidi-years" and not "bidi pack-years" be used. Based on the nicotine content of bidis and cigarettes, it is proposed that the equivalent for 1 cigarette pack-year or 20 cigarette years be taken as 43 bidis per day per year. As each bidi stick has an average of 0.46 times the nicotine content of cigarettes, abstinence of 6–7 h may bring the nicotine level to normal instead of the 12–14 h of abstinence advised for cigarettes. However, with the CO content of bidis being 4.5 times that of cigarettes, it is advised that the minimum duration of cessation of smoking before operative procedures be 24 h as compared to 6 h for cigarettes.

Conflicts of interest
There are no conflicts of interest.

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