Ambulatory Monitoring of Heart Rate and Blood Pressure During the First Week After Smoking Cessation

Marcia M. Ward, Gary E. Swan, Lisa M. Jack, Harold S. Javitz, and John E. Hodgkin

To investigate the timecourse of cardiovascular changes immediately after smoking cessation, 16 subjects wore ambulatory monitors on alternate days during a 1-week residential smoking cessation program. Heart rate was significantly elevated at the time of cessation, then declined steadily until 6 h after cessation, when it reached the level of subsequent nonsmoking days. Systolic and diastolic blood pressures were elevated to a lesser degree for the same period after cessation. The timing of the decline in heart rate and blood pressure was coincident with the timing of an increase in withdrawal symptoms and has implications for laboratory and epidemiologic studies. Am J Hypertens 1995;8:630-634

KEY WORDS: Smoking cessation, heart rate, blood pressure, withdrawal symptoms.

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fter smoking cessation, a chronic smoker's heart rate decreases an average of 8 to 10 beats per minute,1-6 while the effect of smoking cessation on blood pressure remains unclear.4-8 The timecourse of heart rate changes after smoking cessation has been investigated in both short- and long-term studies. With respect to short-term changes, daily measurements for 4 days following cessation indicated that heart rate was significantly lower by the first daily measurement and remained so across the next 3 days.3,4 Regarding long-term effects of cessation, three studies found that the heart rate decline was permanent for up to 1 year,6-10 but one study reported that the heart rate decline reversed fully within 2 months after cessation.11 To our knowledge, one timecourse question that has not been addressed is the rate at which heart rate changes during the first 8 h of abstinence.

This study was conducted to investigate the timecourse of changes in heart rate and blood pressure during the first week after smoking cessation, when smoking withdrawal effects are at a peak.13 This study employed ambulatory monitors that automatically measured heart rate and blood pressure while the subjects were awake and during sleep. Monitoring began within 30 min of cessation, and measurements were repeated on subsequent days to determine when the full change in heart rate and blood pressure levels occurred.

METHODS

Subjects

The subjects were 6 male and 10 female volunteers between the ages of 35 and 73 (mean age,
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52 ± 10) who smoked an average of 37 ± 12 cigarettes per day (range, 10 to 60) and had smoked for an average of 34 ± 9 years (range, 17 to 57). Subjects were participants in a 1-week residential hospital-based smoking cessation program, which used an intensive, tailored, skill-based approach and did not incorporate nicotine replacement therapy.

Procedure The subjects arrived at St. Helena Hospital and Health Center (Deer Park, CA) late Friday afternoon to begin the smoking cessation program. Once they checked into the program, smoking was no longer permitted. Within 30 min of smoking their last cigarette, subjects were assessed for sitting and standing heart rate and blood pressure and expired-air carbon monoxide. Ten of the subjects (Group A) were then fitted with an Accutracker 104AMU (Suntech Medical Instruments, Raleigh, NC) ambulatory monitor to wear from that afternoon until 10:00 AM the next morning, when it was removed prior to exercise. They repeated this procedure on the third and fifth days of the program. The remaining six subjects (Group B) were fitted with the monitors on the afternoon of the second, fourth, and sixth days of the program and wore them until the following midnight. The ambulatory monitor measured heart rate and blood pressure three times an hour while the subjects were awake and once an hour during sleep. At each awake reading, the subjects completed a diary of posture, activity level, and the most frequently reported withdrawal symptoms (intensity of desire to smoke, anxiety, irritability, restlessness, impatience, and difficulty concentrating). In addition, each afternoon the subject’s expired-air carbon monoxide was measured.

Analysis Repeated-measures analysis of variance was used to compare data across the three monitoring days within each group of subjects. Analyses showed that values on the subjects’ second and third monitoring days did not differ from each other, so for the hourly analyses reported here levels during each subject’s second and third monitoring days were averaged and compared with those of their first monitoring day using paired t tests.

RESULTS

Subjects smoked an average of 35% more cigarettes during the hours preceding cessation than their usual level. The CO level at the time of cessation averaged 39 ppm. Within 24 h of quitting, CO levels decreased to 5 ppm and remained less than 5 ppm at each of the five subsequent daily measurements, confirming the subjects’ self-report that they had remained abstinent.

The average hourly ambulatory heart rate and blood pressure levels indicated a marked diurnal activity cycle. Blood pressure and heart rate levels were lowest during the nighttime while the subjects slept and then higher during the day while they were engaged in the program’s individual and class activities.

Within each group, overall average blood pressure and heart rate levels were computed for each monitoring day. These average daily levels did not differ across monitoring days, with the exception of heart rate for the Group A subjects, F(2390) = 7.4, P = .0007, which was significantly higher overall during the first monitoring day than during subsequent monitoring days. Looking more closely, these Group A subjects showed a significant elevation in heart rate levels on the afternoon and evening of the first day of the program. These subjects began monitoring within 30 min of smoking their last cigarette, and at that time their heart rate was noticeably elevated, averaging 90 beats per minute (bpm). Then, as shown in Figure 1, from the second to the sixth hour following cessation, heart rate steadily declined. The magnitude of the decline averaged 12 bpm. To examine the timecourse of this decline, the level at each hour after cessation during the first day of abstinence was compared with the average of the levels at the same time of day on the third and fifth days of abstinence. The difference in heart rate levels during the first hour after cessation was 7.5 bpm, t = 2.2, P = .06; during the second hour it was 13.5 bpm, t = 3.2, P = .02; during the third hour it was 8.0 bpm, t = 3.8, P = .006; during the fourth hour it was 12.5 bpm, t = 3.9, P = .004; and during the fifth hour following cessation it was 4.9 bpm, t = 1.8, P = .10. By the sixth hour after the last cigarette, the heart rate level was nearly indistinguishable (mean difference, 2.7 bpm, t = 1.0, P = .34) from the level at the same time of day on the third and fifth days following cessation.

As shown in Figure 1, blood pressure levels also appeared to be elevated for much of the first 5 h after cessation, but the magnitude of the difference was much smaller than for heart rate. In fact, systolic blood pressure showed significantly higher levels during only the second hour following cessation (mean difference, 8.6 mm Hg, t = 2.6, P = .04), and diastolic blood pressure showed significantly higher levels during only the third hour following cessation (mean difference, 8.2 mm Hg, t = 2.8, P = .03). In contrast to these differences across days observed in the Group A subjects, the Group B subjects who were monitored on days 2, 4, and 6 after cessation showed no significant heart rate or blood pressure differences across days, as shown in Figure 2.

The Group A subjects’ ratings of withdrawal symptom intensity for all six symptoms increased steadily across the first 4 h after cessation, with the change reaching significance for desire to smoke (t = 2.8, P = .04), anxiety (t = 3.1, P = .03), and irritability (t = 2.8, P = .04); in contrast, the Group B subjects who
were monitored on days 2, 4, and 6 after cessation showed no changes. Although withdrawal symptom severity increased in Group A coincident with the decrease in heart rate levels over the first few hours after cessation, withdrawal symptom severity was not correlated with blood pressure or heart rate levels in either group.

**DISCUSSION**

These results indicate that systolic and diastolic blood pressure levels were slightly elevated and heart rate was substantially elevated at the time of cessation. Both blood pressure and heart rate levels declined after cessation; the full extent of the decline did not occur until 6 h after cessation.

These results are consistent with the known effects of smoking. If a single cigarette is smoked after a period of abstinence, blood pressure and, especially, heart rate levels increase dramatically and then return to normal levels within about 2 h.\textsuperscript{15,16} After a few cigarettes are smoked, heart rate and blood pressure remain elevated for some time.\textsuperscript{17} Thus, for the usual smoker, heart rate increases dramatically in the morning as the first few cigarettes are smoked and...
then remains elevated for the duration of the waking hours as more cigarettes are smoked, until the end of the day when the usual smoker stops smoking and heart rate declines. The present results show that in chronic smokers, the stimulatory effect of nicotine on blood pressure and heart rate does not fully diminish for about 6 h, which is consistent with the 2-h terminal half-life of nicotine.

The heart rate decline after cessation in the present study was larger (12 bpm) than that observed previously (average, 8 to 10 bpm). This difference probably reflects not only that these subjects smoked more than usual (mean, 37 cigarettes per day) in general, but also that they smoked an additional 35% more cigarettes during the hours before they checked into the cessation program.

The present results show that self-rated withdrawal symptom intensity increased during the first few hours after cessation, coincident with the decrease in heart rate. Both changes have been linked to decreases in blood nicotine levels.

The present finding that blood pressure and, especially, heart rate do not fully recover until 6 h into abstinence has implications for the timing of mea-

**FIGURE 2.** Systolic and diastolic blood pressure and heart rate average hourly levels during the day after smoking cessation (day 2) and the same hour of day on the fourth and sixth days (day 4 and day 6) following cessation (Group B).
measurements in laboratory studies and in epidemiologic investigations of smokers. For example, laboratory studies of smokers frequently employ a 2-h abstinence period. It is clear from the present data that blood pressure and heart rate are still significantly elevated at this point. Moreover, these cardiovascular measures show a downward trend during the first few hours of abstinence, which could interfere with interpretation of levels during a laboratory study that employed repeated measurements over time. The present findings would suggest an abstinence period of at least 8 h before taking laboratory measurements. For epidemiologic investigations of blood pressure and heart rate levels in smokers, time from last cigarette should be standardized.

**ACKNOWLEDGMENTS**

The authors thank Fran S. Smith and Carol A. Kane for assistance during data collection and the staff of St. Helena Hospital and Health Center, Deer Park, CA, for assistance with recruitment of participants.

**REFERENCES**


10. West R, Schneider N: Drop in heart rate following smoking cessation may be permanent. Psychopharmacology 1988;94:566-568.


