Stage Fright in Musicians: A Model Illustrating the Effect of Beta Blockers

KLAUS A. NEFTEL, MD, ROLF H. ADLER, MD, LOUIS KÄPPELI, PHD, MARIO ROSSI, PHD, MARTIN DOLDER, MD, HANS E KÄSER, MD, HEINZ H. BRUGGESSER, PHD, AND HELMUT VORKAUF, DIPL. PSYCH.

Stage fright was used to investigate the mode of action of beta blockers in acute anxiety and on the technical–motor performance of 22 performing string players. They received 100 mg of atenolol or placebo 6.5 hr before performing either in the presence or absence of an audience. Continuous heart rate, stage fright (especially devised rating scale), technical–motor performance (runs of fast notes, trills, vibratos), and urine catecholamine levels were assessed. Before an audience the placebo group showed a significant impairment of technical–motor performance (increase in the relative variance of repeated fast elements of movements: + 25.68%, $p<0.01$) as compared to performance with no audience present; there was a slight but not significant improvement under beta blockade (− 7.48%). Heart rate was significantly lower under beta blockade than under placebo ($p<0$ 001) Urine catecholamine levels increased twice as much under beta blockade as under placebo before an audience ($p<0.01$). Beta blockade did not influence stage fright measured before performing, but reduced it (measured immediately after the concert) during the concert. We conclude that the drug was at least partially effective as shown by an improvement in technical–motor performance, and that the beneficial effects of beta blockade in stage fright only involve a peripheral site of action.

Since the first tests investigating the effect of propranolol on anxiety performed by Granville-Grossman and Turner (1), many studies have dealt with the anxiolytic effect of beta blockers. Although the direct effects of various beta blockers on the central nervous system (CNS) in humans and animals have been substantiated (2), the current view is that the clinically relevant effects, in this instance, are produced by suppression of anxiety symptoms of a somatic nature and their feedback to the CNS. Accordingly, beta blockers have proved especially useful in anxiety states accompanied by severe somatic manifestations (1, 3). It is thought that the mutual reinforcement of central and peripheral manifestations of anxiety can be interrupted by the drug at the somatic level. This concept was examined in the present study.

We believed stage fright in musicians—defined as an overwhelming sympathetic activation following anticipated anxiety while performing in public—to be an expecially suitable situation to gain useful information: both central anxiety and peripheral sympathetic activation can be properly investigated. In addition, interference or sympathetic activation with technical performance can be assessed in comparison to performance

From the Department of Internal Medicine and Division of Cardiology, University of Berne, Berne; the Laboratory for Electro-Acoustics, Swiss Institute of Technology, Lausanne; and the Institute for Clinical and Experimental Cancer Research of the University of Berne, Berne, Switzerland.

Address requests for reprints to: Dr. Klaus A. Neftel, Department of Internal Medicine, Medical Clinic, University Hospital, 8091 Zurich, Switzerland.

Received for publication September 8, 1981; revision received March 22, 1982.

Published by Elsevier Science Publishing Co , Inc
52 Vanderbilt Ave , New York, NY 10017

0033-3174/82/050461-09$02 75

in a nonanxious situation (i.e., without an audience), as the technical–motor pattern is specifically predetermined by the musical text. Troubles in performance induced by peripheral sympathetic activation may be perceived by both the audience and the soloist and seem to generate a major anxiety reinforcement for the latter.

James et al. (4) found that beta blockers were superior to placebos in alleviating musician's stage fright. Nonbiased musicians judged the performance of violinists under the influence of beta blockers to be significantly better.

In our study we tried to determine the effect of sympathetic activation on specific motor performances and its feedback on stage-fright-related emotions in string players performing in public both with and without beta blockade.

METHODS

Subjects

We examined 9 female and 13 male players of stringed instruments (11 violinists, 5 viola players, and 6 cello players), all of whom performed from 6 to 20 min either as soloists in public or during a conservatory examination. Their age ranged from 20 to 54 years with a mean of 27.6 years. Subjects who exhibited cardiopulmonary, neurological, or psychiatric conditions, or the usual clinical contraindications of beta blockade, were excluded from the study. Participants were not allowed to use any other medication or alcohol and were asked not to change their usual habits on the day of the concert. The performance experience was not assessed. All the players possessed approximately the same level of musical education.

Medication and Grouping

Using a double-blind procedure the participants were randomly divided into two groups. One group received an oral dose of 100 mg of atenolol (Tenormin, ICI-Pharma) 6.5 hr before performance. The other group received a placebo. With regard to instruments the groups were composed as follows: four violin, three viola, and four cello players in the placebo group and seven violin, two viola, and two cello players in the beta blocker group. Four of 11 participants in the placebo group and 5 of 11 in the beta blocker group were female. The mean age in both groups did not differ significantly (25.9 years versus 29.3 years).

We chose to use atenolol because of its hydrophilic qualities, which allow only minimal penetration of the blood–brain barrier (5). After a single oral dose of 100 mg, the plasma level reaches its maximum after 2–4 hr; the elimination half-life is 6–9 hr (6).

Electrocardiogram (ECG)) Monitoring

A continuous ECG was recorded by a Holter monitor from 5 min before until the end of the concert. Pretrial tests showed that the monitor did not interfere with performance, and the subjects had an opportunity to become familiar with the apparatus before the test. The apparatus (16 × 10 × 4 cm), which could not be seen by the public, was set up about 30 min before the performance to allow sufficient time for warming up.

Tape Recording and Analysis

A highly sensitive microphone with an extreme directional sensitivity was used. The technical–motor performance of the musicians was analyzed by means of a sonograph, which allowed a graphic analysis of the frequencies of sound phenomena as a function of time (7). The sonograms consisted of preselected sections of music of 10- to 20-sec duration recorded during the performance (Fig. 1).

Pretrial tests have demonstrated that motor functions can be observed by analyzing runs of fast notes (e.g., arpeggios, trills, and vibrato movements). All of them are characterized by the repetitive occurrence of fast motor elements, i.e., a short single note, a single trill movement, or a single vibrato cycle. Only elements with a duration of less than 0.3 sec were defined as fast. The strict regularity of fast motor elements may be altered during a concert in comparison to performing without an audience. We therefore measured the duration of identical motor

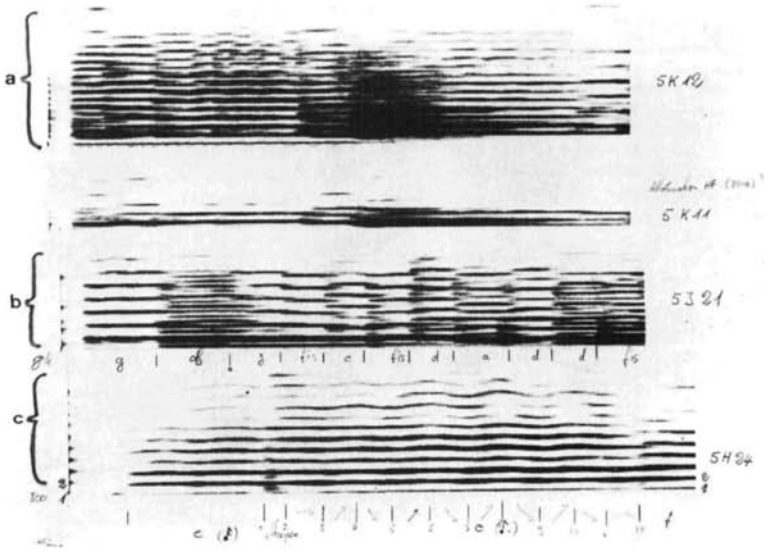

Fig. 1. Three sonogram excerpts of one subject being tested. The abscissa represents time, the ordinate frequency. At each point in time the fundamental tone and the harmonics are recognizable. (a) Trill; (b) run of fast notes; ((c) sustained note with vibrato. (The handwritten notations concern the analysis of the sonograms.)

elements occurring together in the same musical context within the preselected sections of music. The relative variance of the resulting values was then calculated as a parameter of the aberration from theoretical absolute regularity, e.g., the sixteenth notes of six measures from Niccolo Paganini's "Moto Perpetuo" were recorded sonographically and analyzed as described above. Increasing relative variance indicated increasing technical irregularity in playing this section of music.

Stage-Fright Rating Scale

A stage-fright rating scale was presented to the subjects in the last 5 min before they appeared on stage and immediately after the closing applause. The scale consisted of six bipolar statements, marking the two ends of a visual analogue scale (VAS). The subjects indicated with a pencil where they would place themselves on a 100-mm line. The items were measured from the no stage-fright end to the pencil mark in millimeters.

The items were chosen from 60 different statements made by regularly performing violinists and cellists based on their own experience of stage fright. These musicians, however, did not participate in this study. The questions encompassed the mental (questions 1, 6), physical (questions 2, 5), and technical (questions 3, 4) aspects of playing stringed instruments related to stage fright and concerned the areas most frequently mentioned by these musicians.

The six statements and their antitheses were: 1) I am very much looking forward to performing / If I could I would give up. 2) I feel that my physical health is extremely poor / I feel very well. 3) I could not sound better today / I have the feeling I do not at all sound the way I would like to today. 4) I have the feeling that today my specific technical weakness

will not bother me / I fear that my specific technical weakness will disburb me very much today. 5) Right now, I am in possession of an ideal muscle tone in my arms and hands / Right now I feel a severe weakness in my arms and hands. 6) I'm not sure whether I will be in possession of my usual ability / I feel in full possession of my ability today. After the concert the questions were presented in retrospect, e.g., 1) Today, I very much enjoyed playing / I would rather have run away.

Urine Catecholamine Levels

Urine samples were collected starting 3 hr before until 15 min after the performance. They were acidified with perchloric acid to a pH of about 2 and immediately deep frozen. After extraction and purification of the catecholamines (chromatography on aluminum and a strong cation-exchange resin column), the adrenaline and noradrenaline content of the urine was assayed fluorometrically by a modified trihydroxyindole method (8).

Design of the Study

The performance always took place between 8 and 10 P.M. From 4 to 10 days after the concert the performance was repeated at the same time of day without any audience or medication. The subject was allowed to select a familiar setting (his own apartment or practice room in the conservatory). The concert situation is denoted "with audience," the repeat performance "without audience." Figure 2 represents the study design. It permits an intra-individual comparison, i.e., with audience versus without audience, and an interindividual comparison, i.e., beta blocking agent versus placebo..

RESULTS

ECG Monitoring

Figure 3 presents mean heart rates in the placebo group and the beta blocker group, both before an audience and without an audience. As expected, beta blockade significantly inhibited an increase in heart rate when performance was before an audience. Furthermore, it should be mentioned that acceleration of the heart rate under placebo took place only within the last 90 sec preceding the performance. Contrary to the belief of the musicians, their accelerated heart rate remained constant until the end of the performance.

Urine Catecholamine Levels

Figure 4 presents mean catecholamine excretions during the two phases of the experiment. The factors "audience" and "beta blocker" had no significant effects on the volume of urine or on the creatinine excretion compared to the "without audience" situation. We, therefore, compared the entire amounts of cate-

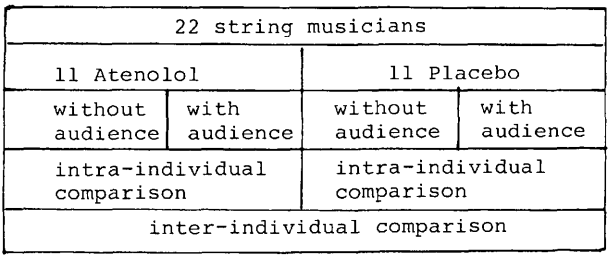

Fig. 2. Study design.

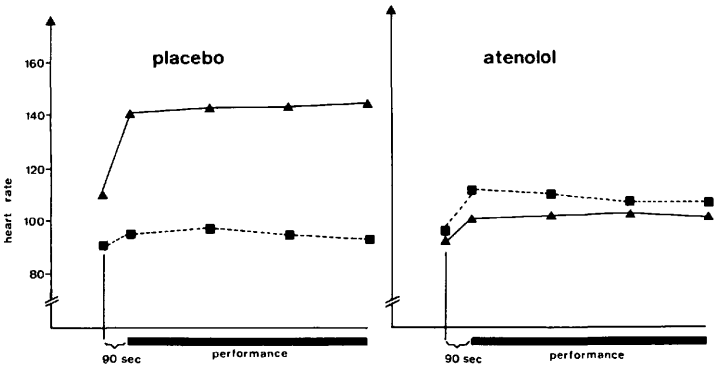

Fig. 3. Mean heart rates before and during performance. (▲) Before an audience; (■) without an audience.

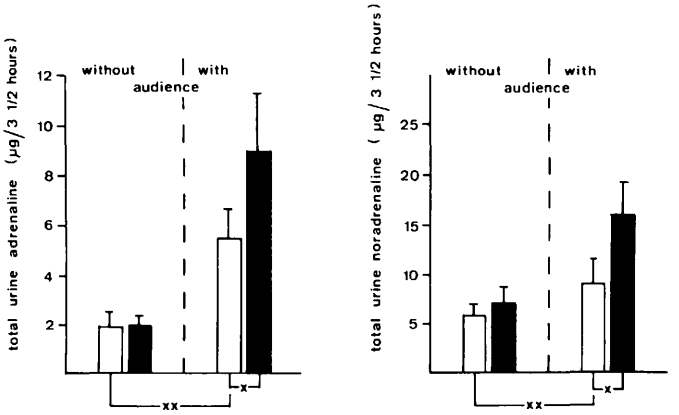

Fig. 4. Urinary excretion of adrenaline (left) and noradrenaline (right) (mean ± SEM). (□) placebo; (■) atenolol; (×) $p < 0.01$; (××) $p < 0.005$.

cholamine assessed in the total volume of urine.

Stage-Fright Ratings

We defined the total stage-fright score as the sum of the answers to the six bipolar questions, as shown in Figure 5. No difference in stage-fright scores could be found between the beta-blocked and the placebo group before the concert. During the concert, stage fright increased in the placebo group, whereas it decreased in the beta-blocked group. Although each

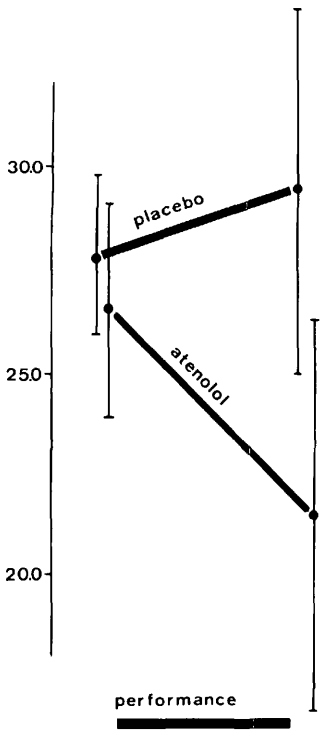

Fig. 5. Total stage-fright score, in millimeters, before and after performance in the presence of an audience (mean ± SEM).

of the six answers confirmed this trend, the total stage fright difference was insignificant ($0.1 < p < 0.2$) because of an increased variance of the scores after the concert as compared to those before the concert. However, the two groups gave significantly different answers to question 2, "I feel that my physical health is extremely poor / I feel very well." Before the concert the placebo group showed a mean of 32.8 mm on the VAS, the beta-blocked group 38.0 mm. After the concert, this aspect of stage fright had risen to 51.2 mm on the VAS in the placebo group, whereas it had decreased to 34.6 mm in the beta-blocked group ($p < 0.01$).

Analysis of the Tape Recordings

We compared the relative variance of groups of repeated, fast elements of certain movements for "with audience" with values for "without audience." The latter was defined as 100%. The relative variance of fast sound sequences with audience was 92.6% in the beta-blocked group, whereas under placebo it was 125.6% ($p < 0.01$). Analysis of the trills and vibrato showed an analogous trend, without reaching the same level of significance.

DISCUSSION

The creation of a stage-fright-provoking stress model for the purpose of drug testing presents inherent and typical difficulties: 1) Replicability of the experiment; 2) development of a nonstress control situation; 3) induction of adequate stress; and 4) assessment of the consequences of stress. The stage-fright model seems to solve certain of the above-mentioned difficulties: Regular performers do not exhibit a learning process of any significance when the experiment is repeated, whereas it is possible to set up a control situation in the form of "without audience." The induced stress is an event occurring routinely in the life of the test subjects, and the stress, in its impact, is comparable that found in car racing, ski jumping, etc. (9, 10). Detailed motor behavior in the experiment can be measured

and can be compared well under stress and control conditions. In our study the greater increase in adrenaline over noradrenaline excretion is typical of sympathoadrenal activation induced by emotional stress (11).

Stress induced by physical activity would be characterized by a predominantly sympathoneural activation with a consequent greater increase in noradrenaline rather than adrenaline excretion. The influence of physical activity can be disregarded in this experiment: Two violinists and one cellist performed their piece a third time without an audience and without being recorded, but with ECG monitoring. The mean heart frequency was 13 beats/min below the values reached without audience but with recording. The subjects showed the same heart frequencies for a physical performance generating only 20–30 W on the electrically braked bicycle ergometer. The recorded performance without audience may therefore already represent stress that is not caused by physical activity alone.

Catecholamine excretion for the beta blockaded subjects "with audience" was double that of performers receiving placebo "with audience," whereas there was no difference in adrenaline or noradrenaline excretion between the groups without audience. Additional enhancement of stress-related increase in plasma and urinary catecholamines by beta-adrenergic blockade under various types of physical stress has been observed previously (12, 13). Our results show a similar effect in sympathetic activation caused by emotional stress. This indicates that the beta-blocking agent does not suppress sympathetic activation but blocks its influence on the target organ.

A difference in the stage-fright level of the two groups became evident only during the performance before an audience. The main sympathetic activation took place less than 90 sec before the performance began, i.e., only after the initial assessment of stage fright. Thus the stage-fright questionnare, which included questions about physical and somatic manifestations of stage fright, discriminated between the conditions "beta blocker" and "placebo" only after sympathetic activity had already increased.

The technical–motor performance was less disturbed under beta blockade than under placebo. Marsden et al. (14) have shown that tremor induced by catecholamines can be suppressed by beta blockers, which probably act through peripheral mechanisms. We cannot prove that the impairment of the motor performance under placebo was only tremor dependent. However, tremor is the main source of technical problems for musicians suffering from stage fright. Subjectively, both the very slow sustained and the very rapid repetitive movements are disturbed. The frequency of the latter is close to that of tremor. The movements studied by us are of the rapid repetitive type, and we assume that suppression of catecholamine-induced tremor is at least partially responsible for the technical improvement.

Since the use of microphones with an extreme directional sensitivity produced substantial alteration of the overall musical result, it was not possible to judge whether performances before an audience or without one were musically better. Technical aspects, however, remained perfectly evaluable: Of 11 participants performing in concert with placebo, 9 could be identified in a blind fashion by a professional violin teacher as being technically hindered by stage fright. In the beta-blocker group, in concert, only one performance was judged as technically

worse, seven as equal to, and three as better than those without an audience. This finding is in agreement with the observations of James et al. (4) showing improvement of both technical and musical performance with beta blockade as judged by professional musicians.

The training of a musician requires the constant focusing of attention on his own performance, "the critical ear" (15). Disturbances of technical performance caused by sympathetic activity may be the musician's main indicator of sympathetic activation during a concert. We, therefore, assumed that improvement of technical performance was a deciding factor in the answers to the stage-fright questionnaire after the concert.

Our results do not necessarily imply a CNS effect of the beta blocker. The favorable effect during a concert can be reasonably explained as a result of its peripheral action. This opinion is supported by the observation that atenolol, with its much lower penetration of the blood–brain barrier, was as effective as propranolol (16), oxprenolol (4), or alprenolol (17), as other studies in musicians have shown.

We assume that the influence of beta blockers on stage fright not only depends on the extent of the somatic symptoms themselves but also on their relationship to the cause of stage fright. (In our study the origin of stage fright was the imperative drive to perform successfully.) This might be of significance in other studies concerning the influence of beta blockers on stress and anxiety. It might provide an explanation as to why an impairment of skilled performances under beta blockade has been observed in certain circumstances (18).

Utilization of beta-blocking drugs for stage fright in performing musicians has some strict medical implications. The more ethical problems involved cannot be discussed in the light of studies such as this one. It is our personal belief that beta blockade in stage fright should only be used under medical control and with well-balanced indications, e.g., a serious impairment of public performance in a professional musician. In our experience, psychological dependency on the beneficial effects of single-dose beta blockade in regularly performing musicians is not a relevant problem. In contrast, the sometimes striking results seem able to reinforce self-confidence for future performances. Therefore, a combination of beta blockade and psychological training methods, as proposed by Brantigan et al. (16), may be a reasonable answer.

CONCLUSIONS

Beta blockade with atenolol has no effect on anticipated anxiety in performing musicians. The effect only becomes evident after the onset of pronounced sympathetic activity. The agent is at least partially effective by an improvement in technical performance that can clearly be shown by sonographic analysis. We suggest that stage fright in players of stringed instruments is favorably modified by the peripheral action of the beta blocker.

This research was supported in part by the Swiss National Foundation for Scientific Research.

The authors thank Urs Frauchiger, Director of the Conservatory of the City of Berne, for providing the opportunity to conduct this study at his institution, and ICI-Pharma for providing the drugs.

REFERENCES

1. Granville-Grossman KL, Turner P: The effect of propranolol on anxiety. Lancet 1:788–790, 1966
2. Koella WP: Anatomical, physiological and pharmacological findings relevant to the central nervous effects of beta-blockers, in Beta-blockers and the Central Nervous System. Edited by P Kielholz. Bern, Hans Huber Publ, 1977, pp. 21–34
3. Tyrer PJ, Lader M: Response to propranolol and diazepam in somatic and psychic anxiety. Br Med J 2:14–16, 1974
4. James IM, Pearson RM, Griffith ANW, Newburg P: Effect of oxprenolol on stage-fright in musicians. Lancet 2:952–954, 1977
5. Neil-Dwyer G, Bartlett J, McAinsh J, Cruickshank JM: β-Adrenoceptor blockers and the blood–brain barrier. Br J Clin Pharmacal 11:549–553, 1981
6. McAinsh J: Clinical pharmacokinetics of atenolol. Postgrad Med J 53 (Suppl 3): 74–78, 1977
7. Leipp E: Acoustique et Musique. Paris, Masson, 1978
8. Käser H: Biochemische Diagnostik des Phäochromocytoms, des Neuroblastoms und anderer neuro-ektodermaler Neoplasien. Helv Paediatr Acta Suppl 29, 1972
9. Taggart P, Carruthers M: Suppression by oxprenolol of adrenergic response to stress. Lancet 2: 256–258, 1972
10. Imhof PR, Blatter K, Fuccella LM, Turri M: Beta blockade and emotional tachycardia; radiotelemetric investigations in ski jumpers. J Appl Physiol 27:366–369, 1969
11. Dimsdale JE, Moss J: Plasma catecholamines in stress and exercise. J Am Med Assoc 243:340–342, 1980
12. Irving MH, Britton BJ, Wood WG, Padgham C, Carruthers M: Effects of β-adrenergic blockade on plasma catecholamines in exercise Nature (Lond) 248;531–33, 1974
13. Hansson BG, Hökfelt B: Long term treatment of moderate hypertension with penbutolol (Hoe 893 d). I. Effects on blood pressure, pulse rate, catecholamines in blood and urine, plasma renin activity and urinary aldosterone under basal conditions and following exercise. Eur J Clin Pharmacol 9:9–19, 1975
14. Marsden CD, Foley TH, Owen DAL, McAllister RG: Peripheral β-adrenergic receptors concerned with tremor. Clin Sci 33:53–65, 1967
15. Galamian I: Principles of Violin Playing and Teaching. Englewood Cliffs, NJ, Prentice–Hall, 1962
16. Brantigan CO, Brantigan TA, Joseph N: The effect of beta-blockade on stage-fright. Rocky M Med J 76:227–232, 1979
17. Lidén S, Gottfries CG: Betablocking agents in the treatment of catecholamine-induced symptoms in musicians. Lancet 2:529, 1974
18. Glaister DH, Harrison MH, Allnutt MF: Experimental cardiovascular stress and the influence of oxprenolol, in New Perspectives in Beta-Blockade, edited by DM Burley, JH Fryer, RK Rondel, SH Taylor. Horsham,England, CIBA Laboratories, 1973, pp. 421–467.