

Flutamide Induces Relaxation in Large and Small Blood Vessels

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Hypothesis: Flutamide, a testosterone receptor antagonist, produces various beneficial effects in male rats following hemorrhagic shock, possibly as a result of a direct vasodilating effect on large and small vessels in the rat.

Design, Interventions, and Main Outcome Measures:

The aorta and the small intestine were isolated from normal male and female Sprague-Dawley rats. Isolated aortic rings were placed in the organ bath and constricted by 2×10^{-7} M norepinephrine bitartrate (Sigma, St Louis, Mo). Flutamide-induced and testosterone-induced vascular relaxation dose-response curves were then determined. The dose-response curves of flutamide were also determined in the small blood vessels of the isolated small intestine under conditions of constant flow following pre-constriction induced by 5×10^{-6} M norepinephrine bitartrate. The effects of prior incubation with testosterone (8×10^{-5} M) and sex differences on flutamide-induced vascular relaxation were also examined in aortic rings and in the small intestine. Moreover, flutamide-induced relaxation in endothelium-denuded aortic rings and in aortic

rings from animals subjected to trauma and hemorrhagic shock was examined.

Results: Flutamide induced significant relaxation in aortic rings and small intestinal blood vessels in healthy males. The flutamide-induced relaxation in vessels from normal males was partially attenuated by prior incubation with the male sex steroid testosterone, and was significantly lower in females. Flutamide-induced vascular relaxation in the aorta was partially attenuated by endothelium removal, but it was not significantly affected by trauma and hemorrhagic shock in male rats.

Conclusions: Flutamide has a direct vasodilating effect on large and small vessels in rats, which involves sex-dependent mechanisms. Thus, the beneficial effects of flutamide on cardiovascular responses in males following trauma and hemorrhagic shock may be due to the direct vascular relaxation induced by this agent.

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FLUTAMIDE, a nonsteroidal testosterone receptor antagonist, has been shown to restore depressed immune function in male mice following trauma and hemorrhage.^{1,2} With regard to organ function, testosterone receptor blockade following trauma or hemorrhage has been shown to improve the depressed cardiac, hepatic, adrenal, and endothelial functions in male rats.³⁻⁵ However, the precise mechanism of the salutary effect of flutamide remains unknown. Previous studies have demonstrated that hypertension and coronary artery disease occur more frequently in men than in age-matched premenopausal women.⁶ Some reports indicate that both the therapeutic use of androgenic steroids and their abuse by athletes are associated with the early onset of cardiovascular and cerebrovascular disease.⁷⁻⁹ Experimental studies further sup-

port the finding that estradiol-treated rats have significantly lower total collagen, a lower collagen-elastic ratio, and higher percentages of elastin in vascular connective tissue than those rats receiving testosterone.¹⁰ Furthermore, systolic blood pressure was highest in rats receiving testosterone and lowest in rats receiving estradiol.¹⁰ Several recent studies¹¹⁻¹⁵ have also demonstrated in vitro the rapid vasodilating effects of estrogen at physiological and pharmacological doses in a variety of animal (eg, canine, rabbit, and rat) and human vascular preparations. Moreover, the rapid vasodilatory effects of estrogen have also been observed in vivo in both nonhuman primates and humans.^{14,16}

Although studies have reported direct effects of estrogen on the vasculature, there is no information available to indicate whether flutamide has any direct effects on the vasculature. We hy-

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pothesized that flutamide directly induces vascular relaxation in large and small blood vessels, and this effect on the vasculature may explain its beneficial effects on organ functions following hemorrhagic shock. The aim of this study, therefore, was to determine whether flutamide directly affects the vascular tone in isolated vessel rings and isolated perfused gut preparations. Moreover, the effects of sex and testosterone on the vascular activity induced by flutamide were examined.

MATERIALS AND METHODS

ANIMALS

Age-matched adult male and female Harlan Sprague-Dawley rats (weight, 275-325 g and 200-250 g, respectively) were studied. All female rats were studied at the proestrus stage of the reproductive cycle, as defined by the presence of both leukocytes and nucleated epithelial cells in approximately equal numbers on vaginal smears. Animals were fasted 16 hours before the experiment but were allowed water ad libitum. This project was approved by the Institutional Animal Care and Use Committee of the University of Alabama at Birmingham.

AORTIC RING PREPARATION AND DETERMINATION OF FLUTAMIDE-INDUCED AND TESTOSTERONE-INDUCED VASCULAR RELAXATION

Immediately after the death of the animals by an overdose of ether, the rat chests were opened and thoracic aortas were rapidly removed. The isolated thoracic aorta was immediately immersed in Krebs-Ringer bicarbonate (HCO_3) solution (composition: 118.3mM sodium chloride, 4.7mM potassium chloride, 2.5mM calcium chloride, 1.2mM magnesium sulfate, 1.2mM potassium phosphate monobasic, 25.0mM sodium bicarbonate, 0.026mM Ca EDTA, and 11.1mM glucose), which was aerated with a mixture of 95% oxygen and 5% carbon dioxide (pH, 7.4; PO_2 , 580 mm Hg). The thoracic aorta was trimmed with care to prevent any damage to vascular endothelial cells and was cut into rings approximately 2.5 mm in length. The aortic ring was carefully mounted on 2 specimen holders and placed in a glass organ chamber containing 20 mL of aerated Krebs-Ringer HCO_3 solution at 37°C. One holder was stationary while the other was connected to an isometric force-displacement transducer (model FT03; Grass Instruments, Quincy, Mass) coupled to a polygraph (model 7D; Grass Instruments). The aortic ring was incubated for 60 minutes at a tension of 1000 mg, during which time the organ chamber was rinsed every 15 minutes with the aerated Krebs-Ringer HCO_3 buffer. When basal tension was stable, a submaximal contraction (approximately 75% of maximal contraction) was induced by $2 \times 10^{-7}\text{M}$ norepinephrine bitartrate (Sigma-Aldrich Corp, St Louis, Mo). The nonsteroidal testosterone receptor antagonist, flutamide (Schering-Plough Corp, Kenilworth, NJ; concentration range, 10^{-5}M to $16 \times 10^{-5}\text{M}$), or an equal volume of propanediol, the non-toxic flutamide vehicle, was applied cumulatively thereafter with or without prior incubation with testosterone (Sigma-Aldrich Corp). Incubation with testosterone ($8 \times 10^{-5}\text{M}$) was begun 15 minutes before norepinephrine-induced ring contraction and was maintained after each wash. After each series of agent additions, the ring preparations were washed with Krebs-Ringer HCO_3 solution and allowed to reequilibrate for at least 30 minutes. Additionally, a dose-response curve to testosterone (concentration range, 10^{-7}M to 10^{-3}M) with or without preincubation with flutamide (10^{-5}M) was performed. Flutamide-induced vascular relaxation was tested in both male and female

rats to assess sex-based differences. Furthermore, flutamide-induced vasodilation was determined in male aortic rings subjected to endothelial denudation. Flutamide-induced relaxation was also examined in aortic rings from male rats at 1.5 hours after trauma-hemorrhage and resuscitation. We have previously described this model of trauma-hemorrhage.⁴

ISOLATED SMALL INTESTINE AND DETERMINATION OF FLUTAMIDE-INDUCED SMALL VESSEL RELAXATION

In additional animals, the right femoral vein was cannulated under isoflurane (1.5%, balanced with air) anesthesia, and the anesthesia was maintained by injection of pentobarbital sodium (30 mg/kg of body weight) via the femoral catheter. Immediately after intravenous injection of 0.5 mL of heparin solution (500 U), the small intestine was isolated without removal from the abdominal cavity. The superior mesenteric artery and the portal vein were cannulated with PE-50 and PE-90 tubing, respectively. The branches of blood vessels to and from the cecum, and the ascending and transverse portions of the colon were then ligated. While the rat was still alive, the isolated intestine was perfused with aerated Krebs-Ringer HCO_3 buffer (a mixture of 95% oxygen and 5% carbon dioxide at 37°C) through the superior mesenteric artery catheter (PE-50). Dextran 70 (6%; Sigma-Aldrich Corp) was added to the Krebs-Ringer HCO_3 buffer to prevent intestinal edema. After 30 minutes of equilibration at a constant perfusion rate of 5 mL per minute, mean \pm SE perfusion pressure was 28.5 ± 1.5 mm Hg. Blood vessels in the isolated intestine were then contracted with $5 \times 10^{-6}\text{M}$ norepinephrine bitartrate, which increased the mean \pm SE perfusion pressure to 113.7 ± 6.1 mm Hg. The vascular responses to flutamide (range, $0.5 \times 10^{-5}\text{M}$ to $8 \times 10^{-5}\text{M}$) with and without prior incubation with testosterone ($8 \times 10^{-5}\text{M}$) were measured thereafter by determining the changes in perfusion pressure in the isolated small intestine. The intestinal preparations were viable throughout the study period, as determined by the similar rise in the norepinephrine-induced increase in perfusion pressure at the end of the experiments vs that at the beginning of the experiments. The vascular responses to flutamide in isolated intestines of male and female rats were compared. It has been reported that resistance blood vessels (ie, small arteries and arterioles), rather than large arteries, play a major role (90%) in maintaining peripheral resistance.¹⁷ Therefore, changes in perfusion pressure in isolated small intestinal preparations reflect the reactivity of small arteries and arterioles in the intestine.

STATISTICAL ANALYSIS

The vascular relaxation responses were expressed as a percentage reduction of the initial vascular tension (ie, $2 \times 10^{-7}\text{M}$ norepinephrine-induced contraction in isolated thoracic aortic ring study and $5 \times 10^{-6}\text{M}$ norepinephrine-induced contraction in the isolated small intestine). Two aortic rings from each animal were studied, and the values were averaged. All data are presented as mean \pm SE. One-way analysis of variance (ANOVA) and Tukey test were employed for the comparison between groups, and the differences were considered significant at $P < .05$.

RESULTS

WEIGHT OF AORTIC RINGS AND ISOLATED INTESTINES, AND NOREPINEPHRINE-INDUCED INITIAL TENSION

Table 1 presents how the weight of aortic rings and the initial tension induced by $2 \times 10^{-7}\text{M}$ norepinephrine

Table 1. Weight of Aortic Rings and Initial Tension Induced by 2×10^{-7} M Norepinephrine*

	Weight, mg	Initial Tension, mg
Males	2.12 ± 0.12	991.8 ± 37.7
Males†	2.08 ± 0.20	930.3 ± 62.7
Females	2.05 ± 0.22	981.1 ± 55.0

*Data are presented as means ± SE (n = 6). Norepinephrine was in the bitartrate form.

†Males with or without testosterone incubation.

Table 2. Weight of Isolated Small Intestine and Perfusion Pressure Induced by 2×10^{-6} M Norepinephrine

	Intestinal Weight, g	Initial Pressure, mm Hg
Males	6.22 ± 0.20	113.6 ± 6.1
Females	6.07 ± 0.20	109.8 ± 8.7

*Data are presented as means ± SE (n = 6). Norepinephrine was in the bitartrate form.

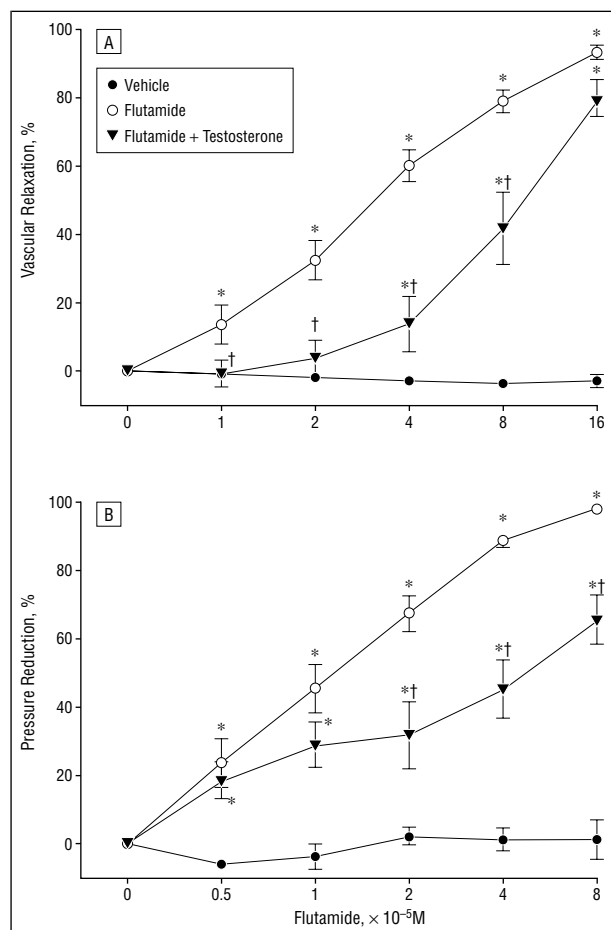


Figure 1. Flutamide-induced vascular relaxation of the aorta and small intestinal vessels from males with or without testosterone. Cumulative dose responses to various concentrations of flutamide, flutamide with testosterone before incubation, and equal volume of propanediol as a vehicle in aortic rings (A) and isolated small intestinal vessels (B) of male rats. Values are expressed as percentages of vascular relaxation from initial vascular tension or pressure reduction from initial perfusion pressure induced by norepinephrine bitartrate. Data are presented as means ± SE (n = 6-7 per group) and were compared by 1-way analysis of variance and Tukey test. Asterisks indicate $P < .05$ vs vehicle; daggers, $P < .05$ vs flutamide alone.

bitartrate were similar between the groups of male rats with and without prior testosterone incubation and between the groups of males and females. The data also demonstrate that the weight of the isolated intestine and the initial perfusion pressure showed no statistically significant difference between males and females (**Table 2**).

EFFECT OF FLUTAMIDE ON LARGE AND SMALL VESSELS IN MALES

Figure 1 indicates the response of aortic rings and isolated small intestines to flutamide in male rats. As shown in Figure 1A, flutamide induced significant dose-dependent aortic vascular relaxation. The apparent threshold for flutamide-induced relaxation was 10^{-5} M flutamide ($13.7\% \pm 5.7\%$), and maximal relaxation ($93.4\% \pm 2.0\%$) was obtained with 16×10^{-5} M flutamide. 1,2-Propanediol (vehicle), however, did not significantly affect aortic vascular tension. Similar results were observed in isolated small intestinal perfusion (Figure 1B). The lowest concentration of flutamide that significantly reduced intestinal perfusion pressure ($23.7\% \pm 7.1\%$) was 5×10^{-6} M, and maximal reduction ($100.0\% \pm 1.35\%$) was obtained with 8×10^{-5} M flutamide. However, 1,2-propanediol did not significantly affect perfusion pressure.

EFFECT OF TESTOSTERONE ON FLUTAMIDE-INDUCED VASCULAR RELAXATION IN MALES

As shown in Figure 1A, the threshold for flutamide-induced aortic relaxation was 4×10^{-5} M with prior testosterone incubation, which was 4-fold higher than the threshold of 10^{-5} M for flutamide-induced aortic ring relaxation without prior testosterone incubation. Furthermore, in the middle-dose range of flutamide (8×10^{-5} M), flutamide-induced aortic ring relaxation in the testosterone incubation group was significantly lower than the relaxation in the group without testosterone incubation. However, at the high-dose range of flutamide (16×10^{-5} M), no statistically significant difference was observed between these 2 groups. Similar results were observed in isolated small intestinal perfusion in male rats. As shown in Figure 1B, flutamide-induced small vessel relaxation in male rats was significantly reduced by prior incubation with testosterone.

EFFECT OF TESTOSTERONE WITH OR WITHOUT FLUTAMIDE PREINCUBATION ON LARGE VESSELS IN MALE RATS

Testosterone induced a significant dose-dependent relaxation in concentrations greater than 10^{-4} M. A maximal relaxation ($53.4\% \pm 13.2\%$) was obtained with 10^{-3} M flutamide (**Figure 2**). Prior incubation with flutamide did not significantly change testosterone-mediated aortic relaxation (Figure 2).

SEX DIFFERENCES IN FLUTAMIDE-INDUCED VASCULAR RELAXATION

The threshold for flutamide-induced aortic relaxation was 4×10^{-5} M in females (**Figure 3A**), which was 4-fold

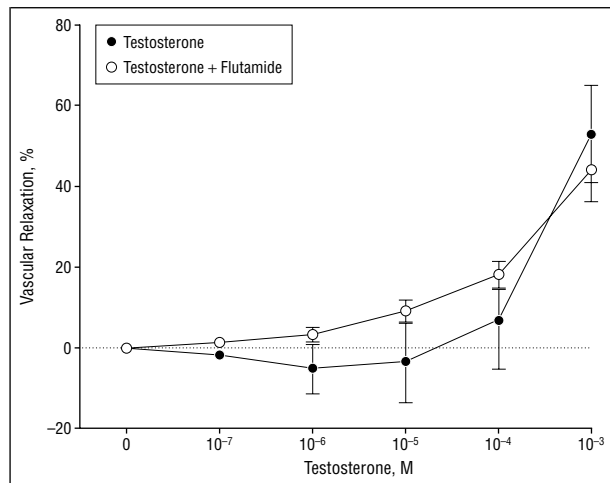


Figure 2. Testosterone-induced vascular relaxation in aortic vessel rings from male rats with or without testosterone. Cumulative dose responses to various concentrations of testosterone and testosterone with flutamide before incubation in aortic rings of male rats. Values are expressed as percentages of vascular relaxation from initial vascular tension or pressure reduction from initial perfusion pressure induced by norepinephrine bitartrate. Data are presented as means \pm SE (n=4-7 per group). A 1-way analysis of variance indicates that there was no statistical difference between the 2 groups at any concentrations tested.

higher than the threshold in males (10^{-5} M). Furthermore, flutamide-induced aortic ring relaxation at various concentrations in females was significantly lower than the relaxation achieved by comparable concentrations of flutamide in males. Similarly, flutamide-induced reductions in isolated small intestine perfusion pressure at 2×10^{-5} M, 4×10^{-5} M, and 8×10^{-5} M were significantly lower in females than in males (Figure 3B).

EFFECTS OF ENDOTHELIUM DENUDATION AND TRAUMA OR HEMORRHAGIC SHOCK ON FLUTAMIDE-INDUCED VASCULAR RELAXATION IN MALE RATS

Flutamide-induced vascular relaxation in endothelium-denuded aortic rings was partially attenuated compared with the rings having intact endothelium (Figure 4A). The entire response curve to flutamide was displaced to the right approximately 10% to 20% in aortic rings without endothelium compared with aortic rings with intact endothelium. However, data in this study show that the relaxation induced by flutamide was not significantly different in aortic rings from sham and from animals 1.5 hours after hemorrhagic shock and resuscitation (Figure 4B).

COMMENT

Our previous studies have shown that flutamide, a testosterone receptor antagonist, restores the depressed immune function in male mice following trauma and hemorrhagic shock.^{1,2} Flutamide treatment also prevents vasoconstriction by testosterone^{18,19} and improves cardiac, hepatic, adrenal, and endothelial functions in male rats following trauma and hemorrhagic shock.³⁻⁵ Therefore, we hypothesized that testosterone receptor blockade by flutamide would relax vessels, and that this effect

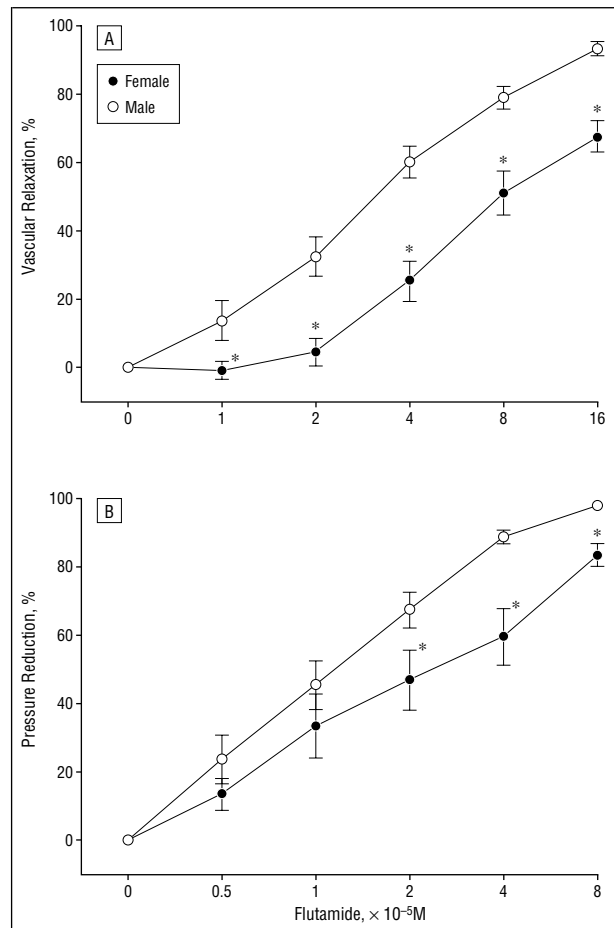


Figure 3. Flutamide-induced vascular relaxation in the aorta and small intestinal vessels from males and females. Cumulative dose responses to various concentrations of flutamide in aortic rings (A) and isolated small intestinal vessels (B) from male and female rats. Values are expressed as percentages of vascular relaxation from initial vascular tension or pressure reduction from initial perfusion pressure induced by norepinephrine bitartrate. Data are presented as means \pm SE (n=6-7 per group) and were compared by 1-way analysis of variance and Tukey test. Asterisks indicate $P < .05$ vs male.

on the vasculature could be useful in the treatment of depressed organ function following trauma and hemorrhagic shock. The aim of our study, therefore, was to determine the effect of flutamide on the thoracic aorta and the small vessels of the small intestine in rats.

The results of the present study indicate that flutamide induced significant relaxation of large vessels and small vessels in rats. The effective dose ranges for flutamide-induced relaxation in large and small vessels in male rats were 10^{-5} M to 16×10^{-5} M and 0.5×10^{-5} M to 8×10^{-5} M, respectively. Our studies have shown that a dose of 25 mg/kg of flutamide significantly improved the function of various organs following trauma and hemorrhage shock in vivo.³⁻⁵ In a study investigating the pharmacogenetics of flutamide, Radwanski et al¹⁸ found that after oral intake of 250 mg of flutamide there was a rapid peak in its plasma concentration, and after prolonged treatment with flutamide, a steady state, with plasma levels of 112.7 ng/mL (approximately 0.5×10^{-6} M), developed.¹⁸ We did not measure the plasma levels of flutamide in our experiments; however, in previous studies,^{1,3-5} after trauma and hem-

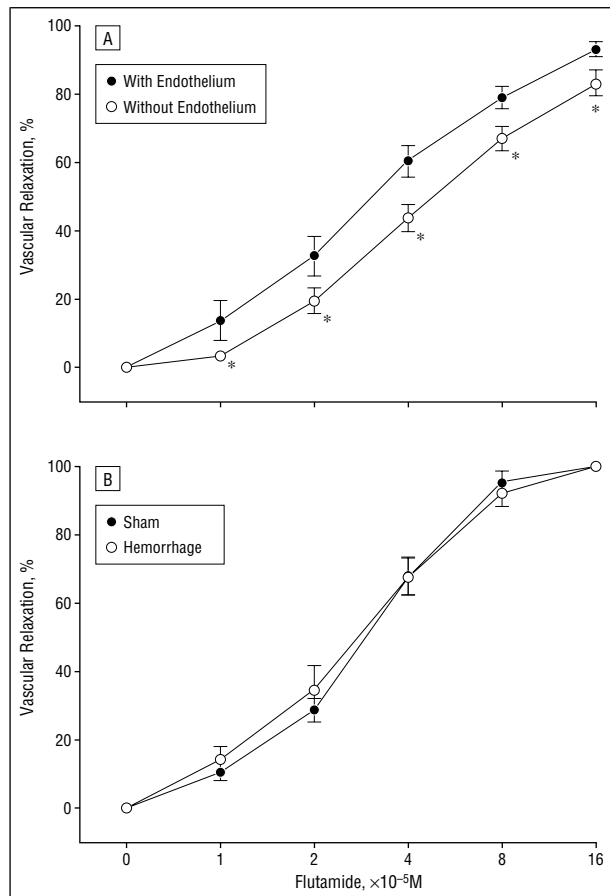


Figure 4. Flutamide-induced vascular relaxation in the male aorta in the presence and absence of endothelium. Cumulative dose responses to various concentrations of flutamide in the aortic rings of male rats. A, Rats with or without endothelium. B, Sham or 1.5 hours after trauma and hemorrhage and resuscitation. Values are expressed as percentages of vascular relaxation from initial vascular tension induced by 2×10^{-7} M norepinephrine bitartrate. Data are presented as means \pm SE ($n=6-7$ per group) and were compared by 1-way analysis of variance and Tukey test. Asterisks indicate $P<.05$ vs with endothelium.

rorhagic shock we subcutaneously treated rodents with 25 mg/kg of flutamide, which is about 9-fold higher than the oral dose of the earlier-cited pharmacogenetic study. Based on this, it seems that plasma concentrations of flutamide reached levels that directly affected the vascular tone in our model. It is interesting that the mesenteric vessel bed showed a higher sensitivity toward the vasodilatory effect of flutamide than did the aorta, and that the response to flutamide was not impaired following trauma and hemorrhage. The reduced perfusion pressure observed in our experiments correlates with the increased intestinal and liver perfusion in flutamide-treated animals following trauma and hemorrhagic shock in previous studies.⁵ Increase of splanchnic perfusion in this model could represent a potential mechanism for the beneficial effects of this agent.

Experiments have also indicated that administration of pentoxifylline or adenosine triphosphate-magnesium chloride following trauma and hemorrhage and resuscitation significantly improves vascular relaxation and has many beneficial effects on experimental animals.²⁰⁻²⁶ In this regard, our present finding of flutamide-induced vascular relaxation in large and small vessels may explain why flu-

tamide can improve depressed organ function in male rats following trauma and hemorrhage.³⁻⁵ Earlier studies in our laboratory have shown that despite resuscitation with a large volume of crystalloid solution after trauma and hemorrhage, microvascular blood flow and oxygen delivery were neither restored nor maintained in various organs such as the liver, intestine, and kidneys.²⁷⁻²⁹ As a consequence of tissue hypoperfusion, cell and organ dysfunction may occur when oxygen delivery decreases below a level adequate to meet regional metabolic demands. This study suggests that flutamide-induced vascular relaxation may increase tissue perfusion and increase oxygen delivery to a level adequate to meet regional metabolic demands and thereby prevent organ failure following trauma and hemorrhagic shock.

The precise mechanism responsible for the flutamide-induced relaxation of vessels remains unknown. Nonetheless, the present results have shown that flutamide-induced relaxation in large and small vessels was significantly reduced by prior testosterone incubation. Additionally, as demonstrated in Figure 1A, in the low- and middle-dose range of flutamide, flutamide-induced aortic relaxation in the testosterone incubation group was significantly lower than relaxation in the group without testosterone incubation. However, at the high-dose range of flutamide, flutamide-induced aortic ring relaxation was not statistically different between these 2 groups. Furthermore, vessels incubated with high doses of testosterone showed a similar relaxation as observed with flutamide. These data may indicate significant competitive antagonism between testosterone and flutamide since a sufficiently high dose of flutamide was able to eliminate the antagonistic effect of a fixed amount of testosterone. Moreover, flutamide-induced relaxation in large and small vessels in females was significantly lower than that in males. The effect of sex and sex steroids on the contractile response of canine coronary and renal blood vessels has been reported.³⁰ Data showed that the maximum isotonic response of the coronary and renal vasculature to the thromboxane A₂-mimetic U46619 was significantly greater in males than in females. Similar sex differences in the contractile response to norepinephrine in the coronary vasculature were also observed. Moreover, pretreatment of male dogs with the antiandrogens flutamide or cyproterone acetate reduced the maximum contractile response of the coronary vessel to thromboxane A₂-mimetic U46619. Pretreatment of female dogs with testosterone resulted in an increase in the maximum contractile response of coronary vessel to U46619.³⁰ Testosterone also has been shown to increase vascular reactivity to norepinephrine in cats.³¹ In the early 1980s, the autoradiographic findings of McGill et al³² demonstrated both estradiol-binding and testosterone-binding sites in the cardiac and vascular tissues of baboons. Similar observations have been made in the walls of large arteries^{33,34} as well as vascular smooth muscle cells.³⁵⁻³⁷ Furthermore, studies have shown the presence of androgen and estrogen receptors on cells.³⁸ Those studies support the notion that testosterone antagonization might have direct effects on the vessel wall.

The present study demonstrated that flutamide-induced vascular relaxation was not strongly attenuated by removal of endothelium from the aortic rings. Therefore,

flutamide-induced vascular relaxation is only partially dependent on endothelium. It has been shown that endothelium-derived nitric oxide, a potent endogenous vasodilator, is identical to endothelium-derived relaxing factor in its pharmacological and chemical properties.^{39,40} However, it remains unknown whether flutamide stimulates the release of nitric oxide from vascular endothelial cells to induce vascular relaxation in the intact vessel. Further experiments in this study indicated that flutamide-induced aortic relaxations were not significantly different between sham animals and those subjected to trauma and hemorrhage. Our previous studies have shown that endothelial dysfunction occurs in the very early stage after hemorrhage and resuscitation.^{20,21} In view of this, nitric oxide release does not seem to be responsible for endothelial dependence of flutamide-induced vascular dilation.

It should be noted that flutamide-induced vascular relaxation in the aorta and small intestine was only partially blocked by prior testosterone incubation or endothelial cell removal. Moreover, the flutamide-induced vascular relaxation was only 10% to 20% lower in females than in males. Furthermore, the similar response to flutamide and high doses of testosterone in our experiments indicates that the mechanisms responsible for flutamide-induced vascular relaxation extend beyond testosterone antagonism and may involve nongenomic and endothelial-independent mechanisms. Increased K⁺ conductance, leading to hyperpolarization of vascular smooth muscle, has been proposed as the mechanism underlying the acute inhibition of vascular contraction by estrogen¹¹ and testosterone.⁴¹ Hyperpolarization of vascular smooth muscle decreases voltage-operated Ca⁺⁺ channel function, inhibits intracellular Ca⁺⁺ release, and lowers the ability of Ca⁺⁺ to activate contractile proteins.⁴² It could be speculated that the nongenomic and endothelial-independent mechanisms of flutamide-induced vascular relaxation involves voltage-operated Ca⁺⁺ channels in vascular smooth muscles, but further studies are needed to determine the exact cellular mechanisms of the direct vascular action of flutamide.

In summary, our results indicate that pharmacological doses of flutamide directly relaxed aortic vessel rings and reduced the perfusion pressure in isolated intestine. This effect was stronger in rings isolated from male rats compared with female rats, but they were not affected by trauma and hemorrhage, and only slightly diminished in vessel rings stripped from the endothelium. Although the inhibition of this action by preincubation of the vessel rings with testosterone suggests an interaction between flutamide and testosterone, and eventually an androgen receptor-dependent mechanism, experiments comparing the effects of flutamide and testosterone in our setup show that the vasorelaxing effect is similar in both agents. Thus, the rapid, nongenomic and endothelium-independent vasorelaxation induced by flutamide in high pharmacological doses appears to be an agonistic effect to testosterone. Further studies should determine the cellular mechanisms of the vasorelaxation after administration of flutamide and its potential therapeutic implications in the treatment of cardiovascular dysfunction after trauma and hemorrhagic shock.

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Occlusion Due to Carotid Artery Dissection: A More Severe Disease Than Previously Suggested

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Background: Stroke due to internal carotid artery dissection is considered to have a good prognosis.

Objective: To determine whether the prognosis of internal carotid artery dissection is worse than classically reported by comparing the characteristics of patients who had an acute ischemic stroke admitted to a population-based primary care center with internal carotid artery occlusion due to either dissection (DO) or atherothrombosis (AO).

Patients and Methods: Among 3502 patients admitted to our population-based primary care center, DO (n=73) was diagnosed by angiography or magnetic resonance imaging, while AO (n=81) was diagnosed by angiography. The characteristics of patients with DO or AO were compared using univariate and multivariate analysis.

Results: Patients with DO were younger (mean [SD] age, 44.6 [10] vs 60.1 [10] years, $P < .001$), had fewer vascular risk factors, and presented more frequently with global middle cerebral artery territory involvement (42% vs 17%, $P < .05$) and less frequently with watershed infarcts (3% vs 19%, $P < .05$) than patients with AO. Unexpectedly, patients with DO were noted to have more severe clinical impairment, with an increased frequency of decreased consciousness, and a poorer outcome at 1 month. Multivariate analysis showed that the independent factors associated with DO were age younger than 55 years, nonsmoker, no history of hypertension, headache at presentation, and global aphasia.

Conclusions: Patients with DO are younger and are initially seen with fewer risk factors than patients with AO, but their clinical features and prognosis are worse. Large infarcts involving the whole middle cerebral artery territory that may be due to the lack of collateral circulation are responsible for the bad prognosis of patients with DO. (2002;59:557-561)

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