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Influence of Chronic Angiotensin-converting Enzyme Inhibition on Anesthetic Induction

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Background: **Several cases of hypotension have been reported in patients who received angiotensin-converting enzyme inhibitors (ACEIs) before a surgical procedure, suggesting that interactions between ACEIs and anesthesia may be neither beneficial nor predictable. To determine if continuation of ACEI therapy until the morning of surgery leads to an unacceptable decrease in blood pressure on induction, we investigated 51 vascular surgical patients that were chronically treated for hypertension with either captopril or enalapril.**

Methods: **After randomization, ACEI therapy was either continued until the morning of surgery or stopped at the time of the preanesthetic visit, at least 12 h (captopril) or 24 h (enalapril) before surgery. Each patient received a standardized anesthetic induction. If systolic blood pressure (monitored using a radial artery cannula) decreased to less than 90 mmHg in response to induction, ephedrine was administered.**

Results: **A marked decrease in plasma converting-enzyme activity was found in patients who received enalapril until the morning of the surgical procedure, and 100% of them required ephedrine after induction. In patients who received their usual dose of captopril on the morning of surgery, plasma converting-enzyme activity was reduced to a lesser extent (when compared with patients who received enalapril). Finally, in the patients in whom ACEI therapy, either enalapril or captopril, was stopped of the evening before surgery, the incidence of induction-induced hypotension was significantly less when enalapril or captopril therapy has been discontinued.**

Conclusions: **These data indicate that in hypertensive patients chronically treated with ACEIs, maintenance of therapy until the day of surgery may increase the probability of hypotension at induction. (Key words: Heart: blood pressure; hypotension. Induction: hemodynamic response. Pharmacology: captopril; enalapril. Surgery: vascular.)**

IT is now widely accepted that hypertensive patients should undergo surgery with a well-controlled blood pressure, and that antihypertensive therapy should be maintained until the day of surgery and restored as soon as possible thereafter.[1] This consensus arises from the evidence that interactions between β-adrenoceptor or calcium channel blockers and anesthesia have beneficial effects, without increasing the hypotensive response to induction.[2–4]

Accordingly, as part of a routine clinical practice, the patient's usual antihypertensive treatment is given before surgery. When angiotensin converting-enzyme inhibitors (ACEIs) were introduced, this same approach was followed in patients receiving these drugs.[5] However, several cases of hypotension in such patients have been reported.[6–9] These exaggerated hypotensive responses to induction suggest that the interaction between ACEIs and anesthesia might not be similar to those observed between β-adrenoceptor or calcium channel blockers and anesthesia.

Thus, the aim of our study was to determine whether continuation of ACEI therapy until the morning of surgery was desirable or not. For this purpose, we investigated hypertensive patients, chronically treated with ACEIs, scheduled to undergo vascular surgery. In these patients, ACEI therapy was, through randomization, either continued until the morning of surgery or stopped at the time of the preanesthetic visit.

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Materials and Methods

Patients

The investigation was approved by the institutional Committee for Safety in human studies of our hospital. Our goal was to study all the patients (1) scheduled for peripheral vascular surgery to lasting more than 2 h, (2) chronically treated with either enalapril or captopril for hypertension, and (3) admitted in our institution at least 3 days before surgery. Informed consent was obtained from 56 patients, 46 men and 10 women, who were to undergo peripheral vascular surgery. All patients had been taking either captopril (25–200 mg/day) or enalapril (10–20 mg/day) for the previous 3 months to 4 yr for the treatment of their chronic hypertension.

Contraindications to study enrollment included the following:

- Treatment with ACEIs for other reasons than chronic hypertension (especially congestive heart failure)
- Systolic blood pressure greater than 170 mmHg at the time of study enrollment
- β-Adrenoceptor blockers or clonidine therapy associated with ACEIs
- History of recent myocardial infarction, unstable angina or ischemic heart disease under nitrates therapy.

Study Design

Three to 5 days before surgery, patients treated with captopril (n = 36) or enalapril (n = 20) were randomized into two groups, in which ACEI therapy was to be continued until the morning of surgery or not. This randomization led to four subgroups: Captopril-continued (n = 17), enalapril-continued (n = 9), captopril-withdrawn (n = 19), enalapril-withdrawn (n = 11).

If ACEI therapy was to be continued, the usual dose taken by the patient every morning was given on the morning of the surgical procedure. To allow assessment interactions between ACEI therapy and anesthesia, the study design required that induction be performed at the time of maximal angiotensin-converting enzyme inhibition. Accordingly, captopril (daily or half daily dose) or enalapril (daily dose) was given respectively 1 and 4 h before induction. In five patients randomly assigned to receive ACEI before induction, the surgical procedure was delayed for scheduling reasons, and induction performed more than 4 h after the time set by the study design. These patients were excluded from the analysis.

If ACEI therapy was to be withdrawn, the treatment was stopped at least 12 h for captopril or 24 h for enalapril.

All patients were premedicated with oral midazolam (5 mg). A cannula was inserted into a radial artery before induction and arterial blood pressure monitored throughout the study period.

A strictly standardized induction technique was prospectively defined and followed. All patients received 6 ml/kg of ringer lactate solution before induction. Anesthesia was induced with midazolam (0.15 mg/kg) and fentanyl (4 μg/kg) while patients breathed 100% oxygen by mask. If these doses did not produce an adequate level of anesthesia, (loss of eyelid reflex), one additional dose of fentanyl (2 μg/kg) and midazolam (0.05 mg/kg) was given. Then vecuronium (0.1 mg/kg) was injected and the trachea intubated by an experienced anesthesiologist. Mean dose of each anesthetic agent, and the amount of fluid given during induction per patient is given in table 4.

After intubation, patients lungs were ventilated with a mixture of oxygen and nitrous oxide (50%/50%). Patients were maintained free of surgical stimulation for 10 min after tracheal intubation. The study ended at skin incision.

For ethical reasons and as a part of the protocol, ephedrine was injected intravenously (6 mg as a first bolus and 3–6 mg as additional boluses) with approximately 100 ml Ringer's lactate to increase systolic blood pressure to 110 mmHg if at any time during the study systolic blood pressure decreased to less than 90 mmHg.

Investigated Parameters

Heart rate and radial arterial pressure were measured before and during anesthetic induction. The maximal blood pressure at the time of or immediately after intubation and the lowest blood pressure measured after induction or during the 10 min during mechanical ventilation without surgical stress were considered for data analysis.

If ephedrine was needed blood samples were withdrawn immediately before ephedrine injection, to obtain plasma catecholamine levels during hypotension.

Biologic Parameters and Plasma Levels of Angiotensin-converting Enzyme Inhibitor

Three to 5 days before surgery, blood samples for ACEI plasma level determination were drawn into tubes containing heparin for captopril or into dry tubes for

Table 1. Clinical Characteristics and Dose ACEI Therapy in the Four Groups of Hypertensive Patients

Group	Enalapril		Captopril	
	Continued	Withdrawn	Continued	Withdrawn
n	7	11	14	19
Age (yr)	65 ± 4	67 ± 5	68 ± 5	66 ± 6
Weight (kg)	70 ± 8	69 ± 7	68 ± 7	69 ± 8
Associated chronic treatment with nifedipine	0	0	2	4
Clinical history of ischemic heart disease (previous infarction, mild angina)	2	4	4	5
Carotid/aortic surgery	5/2	7/4	6/8	10/9
Daily dose of ACEI (mg)	17 ± 4	14 ± 6	73 ± 40	60 ± 20
Time between the last dose of ACEI and induction (h)	4	31 ± 16 (12–60)	1	41 ± 24 (24–72)
Systolic blood pressure (mmHg)*	139 ± 10	145 ± 12	142 ± 9	141 ± 7
Diastolic blood pressure (mmHg)*	75 ± 7	70 ± 8	69 ± 9	72 ± 8
Heart rate (beats/min)*	69 ± 7	72 ± 6	75 ± 8	71 ± 7

Values are mean ± SD; ranges are given in parentheses.

ACEI = angiotensin converting enzyme inhibitor.

* At the time of inclusion of the study, before any change in the antihypertensive regimen.

enalapril determinations, respectively, 1 and 4 h after the last dose.

Blood samples for control determinations of plasma renin activity (PRA) (tubes with ethylenediamine tetraacetic acid), plasma converting-enzyme activity (PCEA) (dry tubes), and plasma catecholamines (tubes with ethylenediamine tetraacetic acid) were drawn 3–5 days before surgery. Additional blood samples for determination of plasma drug levels, PRA, PCEA, and plasma catecholamines were also collected just before the anesthetic induction (preinduction values). Finally, another blood sample was drawn for plasma catecholamine determination after induction (postinduction value), 2 min after the start of mechanical ventilation (5–6 min after intubation), or during the hypotensive response to induction before ephedrine injection.

Plasma was separated, frozen and stored at −20°C (PRA or plasma catecholamines) or at −80°C (PCEA, captopril, or enalapril).

Total captopril[10] and enalaprilate** plasma levels were assessed by radioimmunoassay. PRA was measured using a radioimmunoassay of angiotensin I generated during a standard incubation procedure.[11]

The detection limit of the method was 0.15 $ng \cdot l^{-1} \cdot ml^{-1}$ and coefficients of variation were 5% and 6% for intra- and interassay precision, respectively. PCEA was quantified using the spectrophotometric technique described by Cushman and Cheung.[12] Plasma catecholamines (norepinephrine and epinephrine) were assayed by liquid chromatography with electrochemical detection.[13] The limit of detection of catecholamines was 20 $pg \cdot ml^{-1}$ and the coefficient of variation was 7%.

Data are expressed as mean ± SD. Two-way analysis of variance followed by a Newman-Keuls test and Fisher's exact test was used to assess significance between and within groups. $P < 0.05$ was considered the level of significance.

Results

The four groups of patients were similar with regard to demographic characteristics, (control) arterial pressure measured at the time of inclusion in the study preoperative, and mean dose of ACEI therapy (table 1).

Table 2 summarizes the values of the biologic parameters and of ACEI plasma levels measured in the four groups of patients. There was no significant difference between the control ACEI plasma levels (captopril or enalapril) measured in the two treatment-continued subgroups. In contrast, the preinduction captopril or enalapril plasma levels were markedly decreased or even no longer detectable in the treatment-withdrawn subgroups ($P < 0.001$).

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Table 2. Plasma Captopril or Enalapril Concentrations, Plasma Converting Enzyme Activity, Plasma Renin Activity, and Plasma Epinephrine and Norepinephrine Concentrations Measured 3–5 Days before the Surgical Procedure (Control), before Induction (Preinduction), and after Induction (Postinduction)

Group	Enalapril		Captopril	
	Continued	Withdrawn	Continued	Withdrawn
n	7	11	14	19
ACEI plasma concentration ($ng \cdot ml^{-1}$)				
Control	74 ± 30	45 ± 30	737 ± 520	401 ± 250
Preinduction	68 ± 44	3 ± 3*†	684 ± 560	51 ± 44*†
Plasma converting enzyme activity ($nmol \cdot l^{-1} \cdot min^{-1}$)				
Control	2.5 ± 2.3‡	5.1 ± 3.4‡	13.2 ± 5.9	12.2 ± 4.0
Preinduction	2.8 ± 2.6‡	12.4 ± 8.3*†	11.1 ± 5.0	22.5 ± 5.0*†
Plasma renin activity ($ng \cdot l^{-1} \cdot min^{-1}$)				
Control	401 ± 370	524 ± 400	249 ± 257	226 ± 400
Preinduction	235 ± 211	136 ± 160*	96 ± 65	57 ± 80*
Plasma epinephrine (pg/ml)				
Control	49 ± 13	54 ± 29	56 ± 28	56 ± 27
Preinduction	57 ± 11	75 ± 30	71 ± 45	65 ± 22
Postinduction	56 ± 7	46 ± 32	56 ± 27	52 ± 15
Plasma norepinephrine (pg/ml)				
Control	547 ± 258	635 ± 230	470 ± 300	460 ± 279
Preinduction	427 ± 204	421 ± 201	262 ± 160	394 ± 260
Postinduction	435 ± 428	290 ± 97	272 ± 190	286 ± 160

Values are mean ± SD.

ACEI = angiotensin converting enzyme inhibitor.

* $P < 0.05$ *versus* corresponding control value.

† $P < 0.05$ *versus* corresponding continued value.

‡ $P < 0.05$ *versus* corresponding captopril value.

Control (before treatment modification) PCEA values in the enalapril groups were significantly lower than in the captopril groups. Control PRA and catecholamines plasma levels values were not significantly different between the four groups. In the treatment-withdrawn subgroups, preinduction PCEA values were significantly higher than in the two treatment-continued subgroups (table 2). In the captopril- and enalapril-withdrawn groups, preinduction PRA values were lower but not significantly so than in the corresponding captopril- and enalapril-continued groups.

Finally, control, pre, and postinduction values of plasma epinephrine and norepinephrine did not significantly differ between the four groups.

Even though ACEI therapy was withdrawn in two of the four groups, no difference was found between the mean blood pressure and heart rate values determined in the four groups before induction (table 3). The amount of fluids and anesthetic agents administered for induction is given in table 4. Effects of laryngoscopy and tracheal intubation upon mean heart rate and arterial pressure values did not differ significantly in the four groups (table 3).

The number of patients who experienced abnormal blood pressure responses at intubation and after induction is shown in table 5.

At induction, ephedrine was needed in all patients (100%) who received enalapril before surgery and in 9 of the 14 (64%) who received captopril (nonsignificant). These results contrast with the significantly lower incidence of induction-induced hypotension in the captopril-withdrawn (21%) and enalapril-withdrawn (18%) subgroups (table 5). The lowest systolic blood pressure value recorded after induction was sig-

Table 3. Heart Rate and Blood Pressure Values Measured before Induction, after Induction, at Intubation, and Lowest Recorded Value of These Parameters from after Induction up to 10 min after the Start of Mechanical Ventilation

Group	Enalapril		Captopril	
	Continued	Withdrawn	Continued	Withdrawn
n	7	11	14	15
Heart rate (beats/min)				
Preinduction	69 ± 11	77 ± 11	73 ± 12	73 ± 9
Postinduction	59 ± 12	62 ± 11	60 ± 10	63 ± 12
Intubation	67 ± 9	84 ± 14	75 ± 14	72 ± 13
Associated with the lowest blood pressure	56 ± 8	63 ± 9	56 ± 9	62 ± 11
Lowest value	55 ± 10	59 ± 10	55 ± 9	60 ± 11
Systolic blood pressure (mmHg)				
Preinduction	151 ± 29	164 ± 30	156 ± 28	157 ± 28
Postinduction	84 ± 21	100 ± 17	96 ± 22	108 ± 25
Intubation	120 ± 4	159 ± 38	158 ± 40	162 ± 38
Lowest value	71 ± 10*	100 ± 15†	86 ± 11	101 ± 21†
Mean blood pressure (mmHg)				
Preinduction	105 ± 14	105 ± 14	105 ± 18	105 ± 18
Postinduction	69 ± 16	69 ± 16	73 ± 19	73 ± 15
Intubation	80 ± 14	109 ± 28	108 ± 28	105 ± 28
Lowest value	48 ± 8*	69 ± 15†	58 ± 9	69 ± 17†
Diastolic blood pressure (mmHg)				
Preinduction	62 ± 10	72 ± 10	71 ± 13	76 ± 12
Postinduction	40 ± 8	58 ± 10	45 ± 9	58 ± 11
Intubation	56 ± 4	83 ± 25	77 ± 19	79 ± 22
Lowest value	41 ± 5	55 ± 8	48 ± 6	57 ± 9

Values are mean ± SD.

* $P < 0.05$ *versus* corresponding captopril-continued value.

† $P < 0.05$ *versus* corresponding continued value.

nificantly lower in the enalapril-continued than in the captopril-continued subgroup ($P < 0.05$) (table 3). The lowest systolic and mean blood pressure values were significantly lower in patients who received ACEIs therapy before surgery compared with those in whom these drugs had been withheld (table 3).

Heart rate value noted at the time of the lowest blood pressure, is similar in the four groups (table 3).

Ephedrine effectively increased SBP above 120 mmHg in all patients in whom systolic blood pressure had decreased below 90 mmHg. The mean required dose of ephedrine is given in table 5.

Discussion

To assess whether ACEI therapy should be continued until surgery, a standard practice for other modern antihypertensive agents, we investigated in this study whether stopping the treatment did or did not lead to a hypertensive episode before surgery or at intubation

Table 4. Mean Dose of Anesthetic Agents Used for Induction

Group	Enalapril		Captopril	
	Continued	Withdrawn	Continued	Withdrawn
n	7	11	14	19
Midazolam (mg)	12.5 ± 2.2	13.0 ± 2.3	12.2 ± 2.7	13.2 ± 2.2
Fentanyl (μg)	335 ± 85	375 ± 80	370 ± 90	361 ± 80
Fluid (ml)	771 ± 75	610 ± 40	670 ± 75	640 ± 75

Values are mean ± SD.

Table 5. Number of Patients Who Experienced Hypertensive Episodes upon Arrival in the Operative Room and at Intubation, and Incidence of Hypotensive Episodes Noted after Induction

Group	Enalapril		Captopril	
	Continued	Withdrawn	Continued	Withdrawn
n	7	11	14	19
SBP > 180 mmHg upon arrival in the operative room	1	3	2	3
SBP > 180 mmHg at the time of intubation	0	2	4	3
SBP < 90 mmHg at induction (need for ephedrine)	7*	2	9†	4
Mean dose of ephedrine per patient (mg) (mean ± SD)	11 ± 5	10 ± 4	10 ± 6	10 ± 4

SBP = systolic blood pressure.

* $P < 0.005$ *versus* corresponding enalapril-withdrawn value.

† $P < 0.05$ *versus* corresponding captopril-withdrawn value.

and whether continuing treatment was or was not associated with an unacceptable decrease in blood pressure at induction. Our data obtained in patients chronically treated for essential hypertension with captopril or enalapril demonstrate that withdrawal of ACEI therapy before surgery does not result in a higher incidence of hypertensive episodes both preoperatively and at intubation. In contrast, we noted that the use of ephedrine to maintain blood pressure during induction at systolic levels higher than 90 mmHg was more frequent in the patients who received enalapril or captopril together with their premedication compared with those in whom these drugs had been withheld.

To our knowledge, this is the first study performed in hypertensive patients chronically treated with ACEIs, who received this treatment preoperatively as part of their oral antihypertensive regimen. In all but one of the controlled studies from the literature, ACEIs were administered preoperatively to normotensive untreated patients as an approach toward achieving a potentially beneficial effect by blunting the elevation of plasma levels of stress hormones.[14-17]

The influence of chronic ACEI therapy on anesthetic induction demonstrated in our study markedly differs from that reported with other antihypertensive treatments. Indeed, several studies have indicated that interactions between β-adrenoceptor or calcium channel blockers and anesthesia does not augment the hypotensive response to induction.[2,18] Furthermore, the continuation of these two medications in the preoperative period provides well established beneficial effects, including the prevention of hypertension, dysrhythmias and myocardial ischemia.[2,18]

Several cases of hypotension reported in the literature in patients receiving ACEIs before a noncardiac surgical procedure suggested that the interaction of ACEIs with agents used during induction of anesthesia might lead to adverse hypotensive effects.[5-8,17] The study by Colson et al.[9] suggested that continuing ACEI therapy could accentuate the hemodynamic effect of anesthesia induction. The enhanced decrease in blood pressure observed in our study in patients allocated to receive their treatment with premedication confirms such findings.

This exaggerated hypotensive response to induction is in agreement with previous studies in anesthetized subjects which have shown that angiotensin II contributes to hemodynamic regulation during anesthesia.[19,20] It might also be the consequence of the specific effects of ACEI therapy on the loading conditions of the heart and/or the autonomic nervous system. ACEIs act specifically on peripheral vascular resistance.[21-23] They dilate large arteries as well as resistance vessels. However, vasodilation involves both resistance and capacitance vessels.[24,25] The venodilation due to ACEIs is important to be taken into account when considering the mechanisms by which these agents interfere with the immediate regulation of systemic hemodynamics at induction of anesthesia.

The decreased tone in capacitance vessels might accentuate the decrease in blood pressure provoked by induction through an increase in blood pooling at the expense of cardiac filling. This mechanism is enhanced by the presence of either a preoperative hypovolemia or altered left ventricular diastolic function,[26] both frequently seen in hypertensive vascular surgical patients.[27,28] It is known that the hypertensive patient is

relatively volume-deficient.[28] Volume depletion is the main stimulus of the renin-angiotensin system.[19,20] In addition, the arterial blood pressure of patients chronically treated with ACEIs is characterized by volume dependence.[29]

Chronic ACEI therapy interferes with the function of the sympathetic nervous system and increases vagal tone.[30–33] In this study, a similar heart rate response to induction has been observed in the four groups of patients. Moreover, the epinephrine and norepinephrine plasma levels measured before and after induction were identical when ACEI treatment was continued or stopped before the surgical procedure. These data suggest that the interactions between ACEIs and the sympathetic nervous system are not involved in the exaggerated hypotensive response to induction observed in patients who received their treatment before induction. Rather, these blood pressure changes result mainly from the direct peripheral vasodilator effects of ACEIs. This finding is consistent with studies documenting inhibition of angiotensin II formation as the main mechanism of the blood pressure effect of ACEIs.[22,23,33]

Blood pressure values and ephedrine requirements noted at induction in our study allowed us to better investigate whether or not PCEA and hemodynamic effects are related during induction and during the stress of intubation. Patients receiving enalapril on the morning of surgery form a very homogeneous group. In all these patients, PCEA was negligible (significantly lower than in the captopril-continued patients).

The lower PCEA inhibition observed in patients receiving captopril (*vs.* enalapril) is consistent with previous data from the literature obtained in hypertensive patients.[33,34] Although the PCEA and plasma captopril concentrations values display a wider range, no correlation was found in this group between the magnitude of the decrease in blood pressure and these parameters. The administration of ephedrine (for ethical reasons) when systolic pressure decreased to less than 90 mmHg may explain the difficulty in demonstrating a correlation. However, correlation is lacking probably because the blood pressure response to induction in patients chronically treated with ACEIs depends on several factors other than the intensity of PCEA blockade. Indeed, the blood volume status of the patients and the quality of their systolic and diastolic function might have markedly influenced blood pressure response to induction.

Our study reveals that in patients in whom ACEI therapy was maintained until the day of surgery the decrease in blood pressure after induction was more pronounced in the patients receiving enalapril compared with those receiving captopril (table 4). Other differences concerning tolerance to stress have also been demonstrated between these two agents.[35]

In our study, no cardiac event (postoperative angina myocardial infarction pulmonary edema, or cardiac failure) occurred in the patients in whom ACEI treatment was discontinued. However, a systolic blood pressure higher than 180 mmHg was seen in 20% of these patients. The lack of rebound syndrome has been well established in studies where captopril or enalapril were interrupted in hypertensive patients.[23,33,34] Interestingly, blood pressure and catecholamines plasma levels were not higher in the groups where ACEI therapy was withdrawn. The low incidence of preoperative hypertensive events in patients whose treatment was temporarily stopped is consistent with the partial persistence of the antihypertensive effects of ACEIs for several days after drug withdrawal. Two observations may account for the lack of deleterious increases in blood pressure associated with the preoperative discontinuation of ACEIs. First, after temporary interruption of a chronic ACEI treatment, a persistent tissue angiotensin-converting enzyme inhibition despite a normal PCEA has been described which may account for a maintained antihypertensive effect.[24,36] Second, chronic ACEI treatment exerts long-lasting beneficial effects on the structural and/or functional vascular and myocardial alterations which usually accompany chronic hypertensive disease. As extensively demonstrated in experimental studies, these beneficial effects contribute to the persistence of ACEIs' antihypertensive effects.[37]

Although our study points out that ACEIs may have adverse hypotensive effects when associated with midazolam and fentanyl, this has not proven to be a significant problem if the decrease in blood pressure is rapidly controlled. Hypotension may otherwise compromise organ perfusion pressure. Low cerebral blood flow associated with low mean arterial pressure has been demonstrated in anesthetized patients treated with captopril but not in those receiving a β-adrenoceptor blocker.[38] In our study the observation period was limited to the preinduction and induction periods in patients receiving a tailored form of anesthesia. These periods were investigated because in most documented cases, hypotension in patients who received ACEIs be-

fore anesthesia occurred after induction. A standardized anesthetic protocol allows analysis of a more uniform response of blood pressure to induction and intubation. This affords the opportunity to precisely determine whether preoperative ACEI therapy increases the lowering blood pressure effect of induction. However, because the study examines a small portion of the patients' clinical course, the differences between blood pressure profile depending whether ACEI therapy was either continued or temporarily withdrawn are limited to the preinduction and induction period in patients receiving midazolam and fentanyl for induction.

We conclude that in hypertensive patients chronically treated with ACEIs, therapy until the day of surgery is a major factor influencing blood pressure responsiveness to induction for vascular surgery. If enalapril therapy is continued, a very low PCEA will be observed and an exaggerated hypotensive response may occur at induction. If captopril therapy is continued, the magnitude of the decrease in blood pressure in response to induction, although lower than with enalapril, is enhanced compared with that noted in patients in whom captopril had been withheld. All of the hypotensive episodes in patients who received ACEI therapy until the day of surgery were easily corrected by ephedrine infusion. The temporary withdrawal of these two ACEIs attenuated the hypotensive response to induction but did not lead to an abnormal blood pressure response to induction and intubation. These observations may help to provide the hypertensive vascular patient chronically treated with ACEIs with a stable blood pressure at induction.

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