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Downregulation of the Angiotensin Receptor 1 by Hemopexin In Vitro

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Abstract—During normal pregnancy, in contrast to preeclampsia, plasma hemopexin activity is increased together with a decreased vascular angiotensin II receptor (AT1) expression. We now tested the hypothesis that hemopexin can downregulate the AT1 receptor in vitro. Analysis of human monocytes or endothelial cells by flow cytometry showed decreased membrane density of AT1 exclusively after incubation with active hemopexin, whereas in supernatants of cell cultures, AT1 molecules could be detected (dot blotting). Also, diminished AT1 was observed in endothelial cell lysates after contact with hemopexin (Western blotting). Hemopexin also induced extracellular signal-regulated kinase 1/2 pathway inhibition in cells after stimulation with angiotensin II in vitro, indicating downregulation of AT1 by hemopexin. In addition, functional loss of AT1 occurred after incubation of rat aortic rings with active hemopexin, as reflected by decreased contraction of the aortic rings on stimulation with angiotensin II. It was further demonstrated that plasma from normal pregnant women decreased the AT1 receptor expression on monocytes as compared with plasma from nonpregnant women or preeclamptic women. Finally, it was shown that plasma hemopexin activity increases during normal gestation from week 10 onward. We concluded that active hemopexin is able to downregulate the AT1 receptor in human monocytes, endothelial cells, and rat aortic rings. We propose that the physiological role of enhanced hemopexin activity during healthy pregnancy is to downregulate the vascular AT1 receptor, promoting an expanded vascular bed. Inhibition of hemopexin activity during preeclampsia may result in an enhanced AT1 receptor expression and a contracted vascular bed. (Hypertension. 2009;53:959-964.)

Key Words: pregnancy ■ preeclampsia ■ hemopexin activity ■ angiotensin receptor 1 ■ peripheral vascular resistance

Preeclampsia (PE) is a major complication of pregnancy affecting ≈6% of pregnant women in the Western world. The syndrome is clinically characterized by hypertension, proteinuria, and often edema in the second half of pregnancy. Both severe (early onset) and mild forms of this disorder are recognized, as well as severe variants with liver involvement (hemolysis, elevated liver enzymes, and low platelets syndrome). The etiology of PE is unknown, whereas the pathophysiology is poorly understood. The general consensus at this moment is that a systemic inflammatory response associated with endothelial cell dysfunction plays a central role in the pathophysiology of PE. Current thinking focuses on activation of both inflammatory cells and circulating factors, causing endothelial cell dysfunction. For instance, a soluble fms-like kinase 1, an antagonist of vascular endothelial growth factor, may lead to systemic endothelial alterations, including glomerular endotheliosis.

An important physiological adaptation of normal pregnancy is the increase in cardiac output and blood volume, together with a decrease in peripheral vascular resistance. These physiological changes are already apparent very early in pregnancy and appear to be maximal between weeks 15 and 25 and remain relatively stable until the end of pregnancy. The hemodynamic changes during pregnancy are probably caused (at least in part) by changes in the renin-angiotensin-aldosterone system. One of those changes includes decreased vascular responsiveness to angiotensin II (Ang II), starting approximately at week 10. This drop in responsiveness to Ang II may be attributed to decreased vascular expression of the Ang II receptor (AT1) receptor during normal pregnancy. In PE, however, maternal hemodynamics are characterized by relative hypovolemia, enhanced total peripheral resistance, and impaired uteroplacental perfusion. The contracted vascular bed in these patients is
associated with the persisting vascular responsiveness on Ang II during the entire gestational period.6,7 Accordingly, an upregulation of vascular AT1 receptors, as compared with normal pregnancy, was shown in preeclamptic women.8–11 Plasma hemopexin (Hx), a heme binding glycoprotein, has been shown recently to also exert protease activity.12–14 Thus, Hx is able to affect extracellular matrix (ECM) molecules of renal tissue and endothelial cells in vitro, which can be inhibited by protease inhibitors or nucleotides like ATP.15 Interestingly, enhanced plasma Hx activity occurs in normal pregnant women as compared with nonpregnant or pre-eclamptic women.16 Because this enhanced plasma activity occurs together with downregulation of the vascular AT1 in healthy pregnancy,8–11 we proposed that enhanced Hx activity in healthy pregnant women may be responsible for this downregulation. Because of inhibition of Hx activity by enhanced plasma ATP levels observed in PE,16 it seems likely that AT1 downregulation does not occur, resulting in a contracted vascular bed in these patients.

In the present article, it is shown that the AT1 expression can be downregulated by the active isoform of Hx in vitro in various cell types expressing AT1, including human endothelial cells. Moreover, functional nonresponsiveness on Ang II in blood vessel fragments can be induced by incubation of thoracic arterial rings of the rat with active Hx; these data support the notion that the active isoform of Hx may (during pregnancy) downregulate AT1, resulting in a decrease of peripheral vascular resistance. The lack of vascular expansion in PE in vivo may be related to the absence of active Hx in these patients.

Materials and Methods

Incubation of Peripheral Blood Mononuclear Cells or Human Endothelial Cells With Hx

Peripheral blood mononuclear cells (PBMCs), isolated from EDTA blood samples obtained from healthy volunteers using standard methods, were washed in Hank’s balanced salt solution and resuspended in tissue culture medium (RPMI 1640; 1×10⁶ cells per mL) and incubated with either active Hx (200 μg/mL) or the same amount of heat-inactivated Hx (Hxi) or washed in saline under standard conditions for 2 hours (37°C; 5% CO₂). Hx was prepared by heating at 80°C for 60 minutes. After the incubation, cells were centrifuged (2000 rpm) for 10 minutes; supernatants were collected and frozen (−20°C) until measurement of the AT1 level using Western blot analysis. The cells were resuspended in PBS and analyzed for AT1 receptor expression using flow cytometry (please see the online data supplement).

Aortic-Ring Contraction Studies

The effect of Hx on stimulation of aorta tissue with Ang II was studied using standard isotonic contraction experiments with thoracic aorta rings of the rat pretreated with Nω-monomethyl-L-arginine (L-NNMA) (10⁻⁴ mol/L, for 15 minutes) to inhibit NO synthase according to standard methods.12,13 This assay is based on the protease activity of Hx evaluated after incubation of kidney tissue with plasma samples with or without anti-Hx IgG. Decrease of expression of glomerular ecto-5’-nucleotidase, reflected by a loss of reaction product, indicates Hx activity of the sample tested and is calculated and expressed as arbitrary units of Hx activity.14

EXPERIMENTAL PROCEDURES

PBMCs were obtained from the University Medical Centre Groningen.

Patients

The present study was performed after approval by the medical ethics committee of the University Medical Center Groningen.
The inhibitory effect of preincubation with active Hx on cumulative Ang II concentration-response curves in thoracic aorta rings of the rat. Thoracic rings were preincubated with vehicle (control; rhombus; n=5) or active Hx (10^{-5} mol/L; squares; n=5) for 15 minutes before administration of Ang II. Experiments were conducted in Krebs solution (37°C, 5% CO2, 95% O2), in the presence of 10^{-4} mol/L L-NNMA. Maximum contraction for phenylephrine amounted to 285.1±27.7- and 302.1±60.0-μm transducer displacement in the presence vs the absence of Hx, respectively; this difference was significant (ANOVA for repeated measurements, P<0.01).
incubation of VSMCs with Hx, in contrast to Hxi, leads to decreased staining of the phosphorylated ERK1/2, as reflected in Figure 6.

The studies with plasma samples from either subjects with PE or healthy pregnant women show decreased AT₁ receptor expression in monocytes after incubation with plasma from pregnant individuals as compared with cells incubated with plasma from nonpregnant women (Figure 7). The expression of the AT₁ receptor in monocytes after contact with PE plasma also showed a loss of AT₁ receptor expression, although to a lesser extent as compared with plasma from normal pregnant women. Figure 8 shows mean activities of plasma Hx in samples from healthy pregnant women during the entire period of pregnancy. It appeared that Hx activity gradually increased during pregnancy, starting around week 10.

**Discussion**

The aim of the present study was to test our hypothesis that Hx may be able to downregulate the AT₁ receptor in vitro from cells expressing this receptor. Because both PBMCs and endothelial cells showed a loss of expression of the AT₁ receptor after contact with active Hx (Figure 1), it is likely that active Hx was indeed able to downregulate this receptor. The data in Figure 4A and 4B clearly show that shedding of the AT₁ receptor seems the most likely mechanism. It is clear from Figure 1C and 1D that the outcome of the Hx effect depended on the method of expression of the data. Thus, whereas the mean decrease of the percentage of AT₁-positive monocytes reflected the loss of all of the AT₁ receptors per cell leading to a decrease of a number of positive cells, the mean decrease of intensity (mean channel brightness) reflected the loss of only a part of the receptors per cell after contact with active Hx. It can be deduced from these data that the downregulation of the AT₁ receptors in HUVECs by

**Figure 4.** A. Immunostaining of dots of supernatants from PBMC cultures before and after stimulation with 2 different batches of active Hx (Hxa₁ and Hxa₂) or Hxi, as indicated. Top, Control dots without the first antibody (anti–AT₁, receptor); some faint background staining can be seen. Bottom, In duplo: negative dots (lanes 1 and 2) or slight background staining (lane 3) and positive staining of spots containing supernatants from cultures incubated with either active Hx or Hxi. Lanes 1, 2, and 3 contain Tris-buffered saline, tissue culture medium, and supernatant from unstimulated cell cultures, respectively. It can be seen that the most prominent stained dots are derived from supernatants from cultures incubated with active Hx (Hxa₁ and Hxa₂) vs control culture supernatants derived from cultures stimulated with Hxi (Hxi₁ and Hxi₂). B, Mean staining intensity (±SD) of dots after staining with anti–AT₁, IgG after culture with supernatant from unstimulated cells (●), active Hx (■), or Hxi (□). It is shown that contact with active Hx results in increased amounts of AT₁ receptor (or receptor fragments) in the medium of the cells vs control cells and cells incubated with Hxi. *P<0.01, Hxa vs control and Hxi (Wilcoxon).

**Figure 5.** Western blots of endothelial cell lysates after immunostaining for phosphorylated ERK1/2. It can be seen that lysates from VSMCs derived from Ang II-stimulated cell cultures with previous contact with Hxi show 2 adjacent bands of ~43 kDa, reflecting phosphorylated ERK1 and ERK2 (lane 1). Decreased staining of phosphorylated ERK1/2 can be seen after preincubation of the stimulated VSMCs with active Hx (lane 2). Stimulation of the cell cultures was done with 1.0 nmol/L angiotensin II. Bottom, Loading controls of the same cell lysate samples from cells incubated with either Hx or Hxi, stained for β-actine.

**Figure 6.** Western blots of VSMC lysates after immunostaining for phosphorylated ERK1/2. It can be seen that lysates from VSMCs derived from Ang II-stimulated cell cultures with previous contact with Hxi show 2 adjacent bands of ~43 kDa, reflecting phosphorylated ERK1 and ERK2 (lane 1). Decreased staining of phosphorylated ERK1/2 can be seen after preincubation of the stimulated VSMCs with active Hx (lane 2). Stimulation of the cell cultures was done with 1.0 nmol/L angiotensin II. Bottom, Loading controls of the same cell lysate samples from cells incubated with either Hx or Hxi, stained for β-actine.

**Figure 7.** Flow cytometry data showing mean percentage (±SD) of monocytes expressing the AT₁ receptor after incubation of the cells with plasma from healthy nonpregnant control women (●; n=5), normal pregnant women (■; n=5), and PE patients (□; n=4). It can be seen that cells after contact with plasma from pregnant women (containing active Hx) show decreased expression of the AT₁ receptor. Although considerable downregulation of the AT₁ receptor is also seen after contact of the cells with plasma from PE patients (containing Hxi), this occurs to a significantly lesser extent vs plasma from normal pregnant women. *P<0.01, pregnant plasma vs nonpregnant plasma (Wilcoxon). **P<0.01, PE plasma vs pregnant plasma (Wilcoxon). #P<0.01, PE plasma vs nonpregnant plasma (Wilcoxon).
nonpregnant women (timepoint 0). * Mean Hx activity in plasma samples from weeks 15 to 40 is significantly increased vs mean Hx activity in samples from nonpregnant women (timepoint 0). *P<0.01, Wilcoxon.

active Hx was less prominent as compared with this effect in monocytes. The reason for this remains to be investigated. It is conceivable that the nature of AT1 receptor expression in both cell types is not identical, which may explain this discrepancy.

Be this as it may, it is clear that also in endothelial cells a significant reduction of AT1 expression occurred after contact with active Hx. As concomitant with downregulation of AT1, upregulation of the AT2 receptor occurred after stimulation with Hx (Figure 2), and it is clear that exclusively shedding of the AT1 receptor was induced by active Hx. Both Ang II receptor subtypes AT1 and AT2 were able to bind Ang II. However, downregulation of the AT1 receptor often leads to upregulation of the AT2 receptor. The mechanism of AT1/AT2 interaction after binding of Ang II is poorly understood. Because Ang II receptor trafficking between cell membrane and cytosol occurs, it is conceivable that non-genomic mechanisms are involved in upregulation of AT2 receptors concomitantly with enzymatic removal of AT1 receptors after contact with active Hx. Be this as it may, the present data show an antagonistic effect regarding AT1 versus AT2 expression, which is in line with data from other authors.

Downregulation of the AT1 receptor seems also reflected by inhibition of the contraction of aorta rings by active Hx after stimulation with Ang II (Figure 3). However, although a significant decrease of aorta ring contraction during contact with active Hx is seen in these experiments, it cannot be concluded from these data whether this is because of either enzymatic shedding or blocking of this receptor by active Hx. In view of the present data with isolated cells, however (Figures 1 and 4), it is suggested that enzymatic cleavage of the AT1 receptors by active Hx may be considered as a mechanism by which this nonresponsiveness on Ang II stimulation is induced. Because the contraction induced by the a-adrenergic receptor agonist phenylephrine was not affected by Hx, it seems unlikely that the effect of Hx was caused by a general influence on signal transduction pathways or calcium handling. Therefore, we feel that downregulation of this vascular response on Ang II by active Hx may be specific.

If active Hx is indeed able to promote shedding of the AT1 receptor from cell surfaces, it should be expected that this molecule is detectable in supernatants of cell cultures treated with active Hx. This indeed appears to be the case. The observed increase of the AT1 receptor in supernatants of PBMC cultures after incubation with active Hx, as shown in Figure 4, therefore supports the assumption that active Hx removed the AT1 receptor from the cells studied. This notion is enhanced by the Western blot data of Figure 5, showing reduced AT1 staining in endothelial cell lysates after incubation of endothelial cells with active Hx. Taking advantage of the immediate phosphorylation of the mitogen-activated protein kinase ERK1/2 after stimulation of the AT1 receptor by Ang II, also using this test system, it is clear that downregulation of the AT1 receptor occurred after contact of the cells with active Hx. Because active Hx contains protease activity, able to enzymatically affect various cell membrane constituents and ECM, it is highly likely that this was mediated by the protease activity of active Hx. However, the precise mechanism of this putative shedding of AT1 receptors from cell surfaces remains to be established. Because the blotting technique is based on immunologic detection of AT1 receptor antigens using a polyclonal antibody, it is possible that both the AT1 receptor and fragments of this molecule are recognized. If active Hx also induces shedding of AT1 in vivo, the question as to the function of soluble AT1 emerges. Up to now, a potential function for shedded AT1 receptors or receptor fragments in vivo is unknown. We considered the possibility that active Hx does not enzymatically hydrolyze AT1 directly but acts through stimulation of other membrane-bound enzymes, eg, adamalysin 17. These so-called sheddases are able to promote shedding of various membrane-associated molecules, eg tumor necrosis factor α. Preliminary data, however, showed that inhibition of adamalysin 17, with its inhibitor tumor necrosis factor α protease inhibitor 1, did not affect the downregulation of the AT1 receptor after incubation of the cells with active Hx, suggesting that Hx is able to enzymatically remove the AT1 receptor directly from cell membranes. To exclude the involvement of other sheddases, studies are in progress to test more sheddase inhibitors, including metalloprotease inhibitors. With respect to the AT2 receptor expression, it is clear that AT2 is significantly upregulated by active Hx, suggesting that the balance between AT1 and AT2 expression may be under the control of active Hx (Figure 2). This is in line with the observation that the AT2 receptor may also be involved in vascular responses in normal and complicated pregnancies. However, as stated above, the molecular mechanism underlying AT1/AT2 interactions is unclear.

Similar downregulation of the AT1 receptor occurs when PBMCs are incubated with plasma from healthy pregnant individuals (Figure 7). Because these plasma samples contain active Hx, we ascribe this effect to the presence of Hx in these samples. Incubation of cells with plasma samples from subjects with PE unexpectedly also showed significant downregulation of AT1 receptor as compared with plasma from nonpregnant and pregnant control individuals. This may reflect the presence of Hx activity in these plasma samples. However, using the ECM stripping assay, we demonstrated previously that PE plasma does not show Hx activity. This inhibition is because of the relatively high titers of ATP,
which inhibit Hx activity. The apparent discrepancy obtained in the current experiments, however, can be explained by assuming that contact of PE plasma with living cells expressing ectophosphatasases on their surface promotes hydrolysis of ATP, leading to reactivation of Hx in the PE plasma samples tested. Indeed, experimental evidence is accumulating that contact of PE plasma with living PBMCs may partially activate Hxi in this plasma (results not shown).

In other words, it is likely that this reactivation of Hxi to active Hx has occurred during the incubation steps necessary for the flow cytometry assays. In spite of this disturbing reactivation of Hxi in PE plasma samples, it is clear that plasma from pregnant women contains more Hx activity as compared with that of subjects with PE.

**Perspectives**

Previously we described enhanced Hx activity in plasma from healthy pregnant women, in contrast to women with PE, occurring in the third trimester of pregnancy. From Figure 8, it can be seen that the rise of Hx activity starts approximately on week 10. Also around the gestational age of week 10 in healthy pregnant individuals, the nonresponsiveness on Ang II is observed. This persists throughout the entire period of pregnancy, leading to a relatively expanded vascular bed, beneficial for proper placental perfusion, as compared with age-matched nonpregnant women. Because the nonresponsiveness of vessels on Ang II may be attributable to vascular loss of AT₁, it is tempting to speculate that the function of enhanced Hx activity in normal pregnancy is to promote shedding of the vascular AT₁ receptor, leading to vascular expansion. Interestingly, in healthy pregnant rats, enhanced plasma Hx activity is also associated with decreased AT₁ receptor expression (MM Faas et al, unpublished data, 2009). The hypothesis is in line with the situation in PE lacking Hx activity because of enhanced titers of plasma phosphatase activity and decreased incidence of PE. This suggests that corroboration in vivo, in which smoking, per se, is associated with increased plasma alkaline phosphatase activity and decreased incidence of PE.

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**Disclosures**

None.

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Vascular contraction and preeclampsia. Down regulation of the angiotensin receptor-1 by hemopexin \textit{in vitro}.

Online supplement

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\textbf{Short title:} AT-1 receptor down regulation by hemopexin.

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Expanded Materials and Methods:

Patients
The present study was performed after approval by the medical ethics committee of the University Medical Center Groningen. Written informed consent was obtained from all patients. PE patients and healthy pregnant controls were recruited from the antenatal ward of the University Medical Center Groningen. Blood samples were taken from PE patients and healthy pregnant control women as well as from non-pregnant women. They were recruited from hospital staff and students. Exclusion criteria for all groups were pre-existent hypertension, diabetes mellitus, vasculitis, renal disease, autoimmune disease, malignancy or women who had recent trauma or surgery.

PE was defined according to the standards of the International Society for the Study of Hypertension in Pregnancy (ISSHP): diastolic blood pressure of 90 mmHg or more on two or more consecutive occasions more than 4 hrs apart and proteinuria of more than 300 mg/24 hours. Maternal blood samples of both pregnant and preeclamptic women were collected during routine blood sampling during pregnancy/preeclampsia. Blood samples were drawn from the antecubital vein into 10-mL tubes containing EDTA (Venoject, Terumo Europe NV, Leuven, Belgium). Samples were immediately stored at 4 °C and centrifuged within 1 hour. They were centrifuged at 130 g for 10 minutes at 4 °C; subsequently the plasma was centrifuged at 700 g for 10 minutes. The platelet poor plasma samples were frozen at -80 °C.

Flow Cytometry of PBMC and HUVEC:
To evaluate the expression of AT-1 receptor upon blood cells or HUVEC, PBMC from healthy female donors were washed (x2) in PBS supplemented with 1% bovine serum albumin (PBS/BSA) and subsequently incubated with monoclonal anti AT-1 IgG (clone TONI, Abcam) or anti AT-2 IgG (clone 364805 R&D ;UK), or non immune mouse IgG, at 0 ºC. After 30 min. cells were washed (x2) in PBS/BSA buffer and incubated with goat-anti-mouse IgG FITC (DAKO) for 30 min at 0º C. For control staining, cells were incubated with the second antibody only (i.e. goat-anti mouse-IgG FITC). After another wash (x2) with BSA/PBS cells were fixed with paraformaldehyde (2%). The fluorescence was measured by flow cytometry using a FACS device (Calibur Beckton Dickinson, USA)). PBMC suspensions containing 1x10^5 cells were assayed. The data were processed using a standard software program (Winlist 6.0). For PBMC analysis, monocytes were gated in the forward-sidescatterplot and this gate was copied to a histogram. For HUVEC a gate was set on the HUVEC population and this gate was also copied to a histogram. In the histogram, control incubations (second antibody only) were gated in such way that 99% of the cells were negative for FITC. This gate was then copied to the samples which were incubated with AT-1 receptor antibody. Percentage positive cells was used as a standard for AT-1 expression; mean channel brightness of the positive cells, reflecting AT-1 receptor density, was also calculated.

Dot blot assays for AT-1 receptor in supernatants from PBMC cultures.
For dot blot analysis of the AT-1 receptor in culture-supernatants in PBMC, BioBlot-nitrocellulose membranes (Costar Cambridge Canada) and BioDot apparatus (BioRad Labs) were used. AT-1 receptor was measured in supernatants of cultures from PBMC stimulated with active Hx, Hxi or saline according to standard methods. Supernatants were applied on the membrane (100 µl) and incubated for 60 minutes at
room temperature. The sheets were washed (x4) with Tris buffered saline (TBS). The sheets were removed from the dot blot device and further incubated for 60 min with 5% skim milk (ELK; Campina, The Netherlands) and subsequently washed with TBS supplemented with Tween-20 (0.05%) (TBS-Tween), followed by incubation overnight with the rabbit-anti-human AT-1 receptor IgG (N10; Santa Cruz, USA) and washed with TBS containing 2.0% ELK. After washing (x2) in TBS-Tween, sheets were incubated with goat-anti-rabbit IgG conjugated with alkaline phosphatase (1:2000) for 60 minutes. Stain development was done with nitro blue tetrazolium (NBT) and 5-Bromo-4-chloro-3-indolyl phosphate disodium salt (Sigma-Aldrich, Germany). After drying of the sheets, blots were scanned and the staining intensity was quantified using “Quality One” software program (Biorad).

Western blotting for AT-1 receptor in endothelial cell extracts.
Confluent human endothelial cell cultures (cell line ECV340) were cultured in Medium 199 containing 10% fetal calf serum under standard conditions. After washing with Hanks' balanced salt solution (HBSS), cultures were incubated for 120 minutes with hemopexin (200 μg/ml) under serum free conditions and subsequently washed. Control incubations were done Hxi. After washing with PBS, cell lysates were prepared and subjected to 7.5% SDS polyacrylamide gel electrophoresis (PAGE) and transferred to a nitrocellulose membranes (Biorad) according to standard methods. Cell lysates were prepared by using 150 μl lysis buffer per 6 x 10^5 cells (10mM Tris, pH 7.5; 1 mM EDTA, 4% SDS, 20% glycerol, 10% β-mercaptoethanol, 25mM NaF, containing freshly prepared 100μM Na3VO4, 1mM phenylmethane sulfonnyfluoride ,4 μg/ml aprotinin and bromophenyl blue). The lysates were heated in a boiling water bath for 5 minutes and subsequently sonicated for 5 seconds followed by centrifugation for 10 minutes at 10.000 x g. Samples were subjected to 7.5% SDS polyacrylamide gel electrophoresis (PAGE) and transferred to a nitrocellulose membranes (Biorad) according to standard methods. The membranes were immunostained with mouse monoclonal antibody to the AT-1 receptor (Abcam, ab9391), followed by anti-mouse IgG conjugated with horseradish peroxidase(HRP) according to standard methods. The immunostaining was visualised by enhanced chemiluminescence (SuperSignal West Pico Chemiluminescent Substrate from Thermo Scientific).
Loading controls were done using rabbit polyclonal anti β-actine IgG (Abcam (ab8227)). Thus, before restaining, the blots were incubated with stripping buffer (0.1M glycine containing 1%SDS, pH 2.0) for 30 minutes. The blots were subsequently washed (x3) with Tris buffered saline (pH7.4) and incubated with anti β-actine IgG (1:10.000) for 60 minutes. The staining was visualized as described for anti AT-1 IgG.

AT-1 receptor downregulation by hemopexin in smooth muscle cell lysates as shown by inhibition of the phosphorylation of MAP kinase ERK1/2.
This test system is based upon phosphorylation of the MAP kinase ERK1/2 in cells expressing the AT-1 receptor. This phosphorylation occurs upon binding of angiotensin II (Ang II) to the AT-1 receptor. The protocol used was carried out with vascular smooth muscle cells of Wistar rats (VSMC), which were kindly provided by Dr L.E. Deelman (Department of Clinical Pharmacology, UMCG, Groningen), according to standard methods. Confluent cells (passage 3-6) were cultured in
Dulbecco’s Modified Eagle’s Medium containing 10% fetal calf serum under standard conditions. Before use, cells were washed with HBSS and subsequently incubated with 200 μg/ml Hx or Hxi for 120 minutes under serum free conditions. After incubation cells were washed and incubated with Ang II (1.0 nM/ml)) for 5 minutes followed by the preparation of cell lysates as described above. The lysates were subjected to 10% SDS PAGE followed by blotting to nitrocellulose membranes according to standard methods. Immunostaining was done with a mouse monoclonal antibody against phosphorylated ERK1/2 (Santa Cruz; SC 7383) and by rabbit anti mouse IgG conjugated to HRP (DAKO,PO260) as a second step. The staining was visualized by enhanced chemiluminescence as described above.