

## Noscapine antagonizes vasoconstrictor action of bradykinin in isolated human umbilical artery

Massoud Mahmoudian<sup>1</sup>, Nahid Aboutaleb<sup>2</sup>, Farahnaz Beiranvand<sup>3</sup>  
Ashraf-Alsadat Moazzam<sup>4</sup>, Massoumeh Shafiei<sup>5</sup>

Department of Pharmacology, Medical School, Tehran University of Medical Sciences, Tehran, Iran

Received: 25 Sep 2010

Revised: 18 Dec 2011

Accepted: 18 Jan 2011

### Abstract

**Background:** It has been demonstrated that noscapine, an antitussive opioid alkaloid, could antagonize bradykinin-induced responses such as bradykinin effects in guinea-pig ileum, cough induced by bradykinin receptor agonist and angiotensin converting enzyme inhibitors, and brain damage after brain edema both in neonatal rat model and in patients with stroke. In the present study, the effect of noscapine on bradykinin-induced constriction of human umbilical artery was investigated.

**Methods:** Segments of human umbilical cords were obtained from women with normal full term pregnancies. Concentration-response curves for bradykinin (1-1000 nM) were constructed in the absence and presence of noscapine (1-1000 nM). To show the specificity of noscapine for bradykinin-induced constriction in the tissue, the effect of noscapine (10 pM) on vasoconstriction produced by histamine were also examined.

**Results:** The results showed that noscapine could antagonize the constriction produced by bradykinin in human umbilical artery. It was also demonstrated that noscapine was capable of reducing histamine-induced contractile response.

**Conclusion:** It is concluded that noscapine can antagonize bradykinin-induced constriction of human umbilical artery in a nonspecific manner. Thus, noscapine is likely to find a clinical application in pathologic conditions accompanied by higher vascular sensitivity to bradykinin in pregnancy.

**Keywords:** noscapine, human umbilical artery, bradykinin, histamine.

### Introduction

The kallikrein-kinin system plays an important role in many physiological and pathophysiological conditions such as homeostasis of circulation, inflammation/ allergy, pain, shock, etc. Two types of kinin receptors are known, bradykinin (BK) B<sub>1</sub> and B<sub>2</sub> receptors. B<sub>2</sub> receptors are constitutively expressed and mediate most physiological ac-

tions of kinins, whereas B<sub>1</sub> receptors are highly inducible upon inflammatory stimulation or tissue injury, suggesting that they are involved in inflammation and/or nociception [1]. Numerous BK antagonists have been developed in recent years with the prime aim of treating diseases resulting from excessive BK formation. Such BK receptor antagonists may have novel therapeutic applications in various pathological conditions associated

1. Professor, Department of Pharmacology, Medical School, Tehran University of Medical Sciences, Tehran, Iran. [masmah99@tums.ac.ir](mailto:masmah99@tums.ac.ir)

2. Assistant Professor, Department of Physiology, Medical School, Tehran University of Medical Sciences, Tehran, Iran. [dr\\_nabo40@yahoo.com](mailto:dr_nabo40@yahoo.com)

3. MSc, Department of Physiology, Medical School, Tehran University of Medical Sciences, Tehran, Iran. [fbeiranvand@yahoo.com](mailto:fbeiranvand@yahoo.com)

4. BSc, Department of Pharmacology, Medical School, Tehran University of Medical Sciences, Tehran, Iran. [ashmoazzam@yahoo.com](mailto:ashmoazzam@yahoo.com)

5. (Corresponding author) Associate Professor, Department of Pharmacology, Medical School, Tehran University of Medical Sciences, Hemmat Highway, P.O.Box: 14155-6183, Tehran, Iran. Tel: +9821-88052979 [m-shafiei@tums.ac.ir](mailto:m-shafiei@tums.ac.ir)

with abnormal kinin system [2]. It has been demonstrated, in our laboratory, that noscapine, a non-narcotic antitussive opioid alkaloid, specifically antagonizes the contractile response of BK in guinea-pig ileum [3], interferes with cough induced by a BK B<sub>2</sub> receptor agonist, ie, FR190997, and angiotensin converting enzyme inhibitor (ACEI), ie, enalapril, in guinea-pig [4], and attenuates BK-mediated brain damage after brain edema both in neonatal rats with a hypoxic-ischemic insult [5] and in patients with acute ischemic stroke [6]. Because of noscapine safety [7], the newer medical applications of the drug would be desirable. In the present study, the effect of noscapine on BK-induced constriction of isolated human umbilical artery (HUA) was investigated. Umbilical artery plays an essential role in adequate perfusion and nutrition of the placenta and is sensitive to kinins [8]. It has been shown that BK results in constriction of HUA through B<sub>2</sub> receptors [9]. To show the specificity of noscapine against BK-induced constriction in this tissue, its action on vasoconstriction produced by histamine was also examined.

## Methods

### *Tissue preparation*

Segments of human umbilical cords were obtained from women with normal full term pregnancies. Immediately after delivery, a 7-8 cm long segment of the umbilical cord was taken from the placental portion. This area of the cord is known to be nerve free [10-12]. Cords from mothers exhibiting eclampsia, hypertension, diabetes, a Rhesus problem or other overt diseases were not included in the study. Cords from mothers taking medication, such as antihistamines, morphine, adrenergic blockers or anticholinergic drugs during near term period were also excluded. All procedures had Institutional Ethical Committee approval. The cords were immediately placed in cold (4°C) Krebs solution (see below). The arteries were dissected free of the Wharton's jelly within 1 h. Care was taken in the dissection, to minimize handling in order to prevent tissue dam-

age and prostaglandin release [13,14] which could cause constriction of the isolated HUA [15,16]. A magnifying lens was always used during the preparation procedure. The arteries with an intact endothelium (confirmed histologically), were cut into 3-4 mm long ring segments and suspended under 2 g tension in 10 ml organ bath. The organ bath contained Krebs solution of the following composition (in mM): NaCl 118, KCl 4.8, CaCl<sub>2</sub> (2H<sub>2</sub>O) 2.5, MgSO<sub>4</sub> (7H<sub>2</sub>O) 1.2, KH<sub>2</sub>PO<sub>4</sub> 1.2, NaHCO<sub>3</sub> 25 and glucose 10. The temperature was thermostatically maintained at 37°C and the solution was aerated with 95% O<sub>2</sub> and 5% CO<sub>2</sub>. A 2-h equilibration period was allowed before the administration of the agonist and during this time Krebs solution was changed every 15 minutes. Responses were measured with isometric tension transducer (F90-NARCO, USA) coupled to a polygraph. Tissues that exhibited spontaneous activity were not utilized in the experiments.

### *Individual protocols*

Ascending concentrations of the vasoconstrictor agonist, ie, BK (1-1000 nM), were added to the organ bath cumulatively to generate a concentration-response curve. Subsequent concentration-response curve for BK was constructed in the presence of noscapine, as an inhibitor. A washout period of at least 90 min was allowed between constructing the two concentration-response curves. During the washout period, Krebs solution was changed every 15 min. When inhibitor was used, different concentrations of noscapine (1, 10, 100 and 1000 nM) were added to the bath and tissue allowed to equilibrate for 30 min before the agonist concentration-response curve was repeated. In each individual preparation, concentration-response curves for BK in the absence and presence of only one concentration of noscapine were constructed. To show the specificity of the inhibitory action of noscapine for BK-induced constriction, the effect of noscapine (10 pM) against histamine-induced vasoconstriction was also assessed.

Agonist potency was expressed as pEC<sub>50</sub>

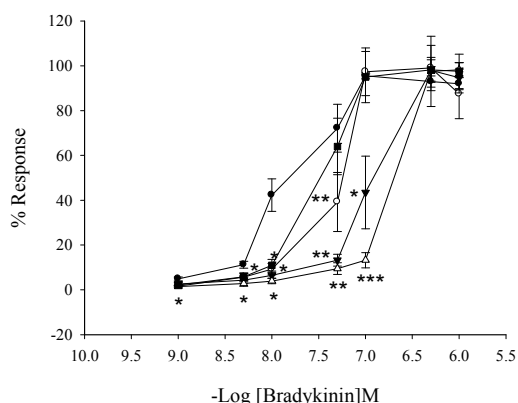


Fig. 1. Mean constrictor concentration-effect curves to BK alone (●), on human isolated umbilical artery and in the presence of 1 (Δ), 10 (▼), 100 (○) and 1000 (■) nM noscapine. Each point represents arithmetic mean ± S.E.M of six experiments. \*p<0.01, \*\*p<0.001, \*\*\*p<0.0001, significant difference between BK alone and in the presence of noscapine.

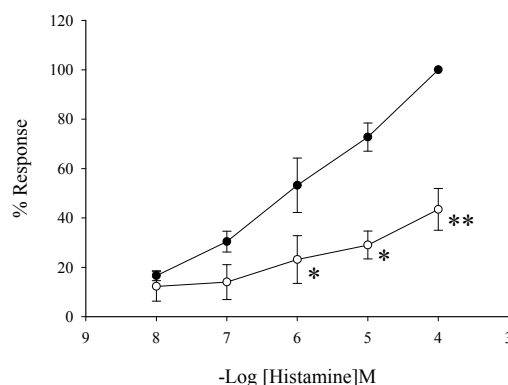


Fig. 2. Mean constrictor concentration-effect curves to histamine alone (λ), on human isolated umbilical artery and in the presence of 10 pM noscapine (μ). Each point represents arithmetic mean ± S.E.M. of six experiments. \*p<0.05, \*\*p<0.01.

value which defined as the negative logarithm of the concentration required to produce a response equivalent to 50% of the maximal response elicited by the agonist. pEC50 values for BK alone and in presence of different concentrations of noscapine were used to compare the differences between the inhibitory responses caused by noscapine and control.

**Drugs**

BK and histamine was obtained from Sigma Chemical Company, Germany. Noscapine was obtained from Temad Pharmaceutical Company, Tehran, Iran. BK was dissolved in distilled water and final drug solutions were made up in saline (0.9% w/v NaCl). A 10 mg/ml noscapine stock solution

was prepared in 0.1 M acetic acid and diluted with saline to obtain final solutions. Histamine solutions were also made up in saline.

*Statistical analysis*

All data are expressed as arithmetic means ± standard error of mean (SEM) of n experiments. Student's t-test used for analysis and differences were considered significant when p<0.05. All statistical analyses were carried out using SigmaPlot software, and EC50 values are expressed as pEC50.

**Results**

Noscapine alone in concentrations used in this study had no effect on the tone of HUA rings. Cumulative addition of BK (1-1000 nM) resulted in concentration-dependent constriction of HUA rings. Noscapine (1, 10, 100 and 1000 nM) antagonized the constriction produced by BK (Fig. 1). Although the presence of ascending concentrations of noscapine did not affect the BK-induced maximal response but the lowest concentration (1nM) caused the greatest shift of BK concentration-response curve to the right. On the contrary, the highest concentration of noscapine used in the experiment (1μM) produced the least inhibition against BK-induced constriction of HUA rings (Fig. 1).

Table 1. pEC50 values for bradykinin (BK) in the absence and presence of noscapine (1, 10, 100 and 1000 nM).

Concentration of noscapine (nM)	pEC50 values for BK
-	8.81 ± 0.16
1	7.55 ± 0.06*
10	7.73 ± 0.3**
100	8.46 ± 0.25
1000	8.33 ± 0.25

\* p< 0.01 \*\*p< 0.0001 vs pEC50 value for BK in absence of noscapine

The pEC50 values for BK in the absence and presence of noscipine are presented in Table 1. Noscipine (10 pM) caused an inhibition against histamine-induced constriction in HUA ring segments as well (Fig. 2).

### Discussion

The results presented in this study indicated that noscipine might antagonize the constriction produced by BK and also histamine in HUA ring segments. It has been previously reported that noscipine, being used clinically as an antitussive drug, could antagonize BK-induced contraction of isolated guinea-pig ileum in a non-competitive manner while it did not inhibit the responses to acetylcholine, histamine, serotonin or angiotensin II [3]. Moreover, in another study, noscipine was able to suppress cough induced by an ACEI and an agonist of BK B<sub>2</sub> receptor. Decreased degradation of BK has been proposed as a major mechanism involved in ACEI-induced cough [17]. This antitussive effect of noscipine was not mediated through the  $\mu$ ,  $\kappa$  or  $\delta$  opioid receptors and it was proposed that noscipine might interfere with the BK cough mediation [4]. It has also been shown that noscipine could reduce brain injury after hypoxic-ischemic insult in neonatal rats as a model of brain edema [5] and was effectively able to attenuate the postischemic brain edema and reduce the mortality rate in patients with stroke [6]. BK is known to contribute to neural tissue damage as well as to long lasting disturbances of the blood-brain barrier function through activation of B<sub>2</sub> receptors [18-20] and a BK B<sub>2</sub> receptor antagonist, LF 16-0687 Ms, was demonstrated to enhance the neurological recovery in a rat model of temporary focal cerebral ischemia [21]. In the present study, noscipine antagonized BK-induced constriction of isolated HUA. This BK action was previously demonstrated to be exerted through B<sub>2</sub> receptors [9]. The antagonism against BK was inversely dependent on noscipine concentrations. In nearly all experiments performed in our lab, noscipine was shown to have an inverted U shape biphasic response depending on the

concentration range used in the experiment. Obtaining the greatest inhibitory effect of noscipine, although non-specific, with the lowest concentration of the drug resembled the findings presented by Zausinger et al. [21] and Plensila et al. [22] who have achieved beneficial results when using a lower dose of specific non-peptide competitive B<sub>2</sub> receptor antagonist, LF 16-0687 Ms. Furthermore, Relton et al. [23] when using a selective peptide-based B<sub>2</sub> receptor antagonist, CP-0596, demonstrated that the higher dose of B<sub>2</sub> antagonist failed to affect brain edema after induction of a focal lesion. With regard to pEC50 values and maximal responses of BK in presence of different concentrations of noscipine, it seems that noscipine caused a competitive inhibition of BK action in HUA. However, noscipine attenuated histamine contractile response as well and did not show specificity against BK-induced constriction in this human tissue. So it can be deduced that noscipine may play a physiologic antagonistic role against BK in HUA.

BK is a vasoactive kinin that is present in fetal circulation and has an important role in local regulation of vascular tone in the placental and umbilical blood vessels [8,24]. Significant potentiation of BK-induced vasoconstriction in HUA from pregnancy-induced hypertension (PIH) has been previously reported [25]. Thus, vascular sensitivity to BK is likely to be enhanced in hypertensive pregnancy. Regarding the safety of noscipine [7] and its very potent inhibitory effects against BK-induced HUA constriction, future investigations could be proposed for possible application of the drug in pathological conditions, such as PIH, in pregnancy.

### Conclusion

It is concluded that noscipine can antagonize BK-induced constriction of HUA in a nonspecific manner. Thus, further studies are required to elucidate if noscipine could find a clinical application in pathologic conditions accompanied by higher vascular sensitivity to BK in pregnancy.

## References

1. Hirayama Y, Kayakiri H. Bradykinin antagonists: current status and perspective. *Nippon Yakuriga-ku Zasshi* 2002; 119 (1):45-53.
2. Sharma JN, Al-Dhalmawi GS. Bradykinin receptor antagonists: therapeutic implications. *IDrugs* 2003; 6 (6):581-6.
3. Mahmoudian M, Mojaverian N. Effect of noscapine, the antitussive opioid alkaloid, on bradykinin-induced smooth muscle contraction in the isolated ileum of the guinea-pig. *Acta Physiol Hung* 2001; 88 (3-4):231-7.
4. Ebrahimi SA, Zareie M-R, Rostami P, Mahmoudian M. Interaction of noscapine with the bradykinin mediation of the cough response. *Acta Physiol Hung* 2003; 90 (2):147-55.
5. Mahmoudian M, Siadatpour S, Ziai SA, Mehrpour M, Benaissa M Nobakht M. Reduction of the prenatal hypoxic-ischemic brain edema with noscapine. *Acta Physiol Hung* 2003; 90 (4):313-8.
6. Mahmoudian M, Mehrpour M, Benaissa M, Siadatpour Z. A preliminary report on the application of noscapine in the treatment of stroke. *Eur J Clin Pharmacol* 2003; 59 (8-9):579-81.
7. Ke Y, Ye K, Grossniklaus HF, Archer DR, Joshi HC, Kapp JA. Noscapine inhibits tumor growth with little toxicity to normal tissues or inhibition of immune response. *Cancer Immunol Immunother* 2000; 49 (4-5):217-25.
8. Gobeil LH, Pheng I, Badini I, Nguyen-Le XK, Pizard A, Rizz,i A., et al. Receptors for kinins in the human isolated umbilical vein. *British J Pharmacol* 1996; 118:289-94.
9. Abbas F, Clayton JK, Marshall KM, Senior J. Characterization of kinin receptors on the human isolated umbilical artery. *J Endocrinol* 1998; 156:389-94.
10. Altura BM, Malaviya D, Reich CF, Orkin LR. Effects of vasoactive agents on isolated human umbilical arteries and veins. *Am J Physiol* 1972; 222 (2):345-55.
11. Bodelsson G, Stjernquist M. Characterization of contractile adrenoceptors in the human umbilical artery. *Eur J Pharmacol* 1995; 282 (1-3):95-101.
12. Davingdon J, Lornez RR, Shepherd JT. Response of human umbilical artery to changes in transmural pressure. *Am J Physiol* 1965; 209 (1):1-9.
13. McGrath JC, MacLennan SJ, Stuart-Smith K. Characterization of the receptor mediating contraction of human umbilical artery by 5-hydroxytryptamine. *Br J Pharmacol* 1985; 84 (1):199-202.
14. Piper PJ, Vane JR. The release of prostaglandins from lung and other tissues. *Annals of New York Academy of Sciences* 1971; 180:363-85.
15. Bjoro K, Stray-Pedersen S. In vitro perfusion studies on human umbilical arteries. I. Vasoactive effects of serotonin, PGF<sub>2</sub> and PGE<sub>2</sub>. *Acta Obstet Gynecol Scand* 1986; 65 (4):351-5.
16. DeMoraes S, Carvalho JCC, Cavalcante MT, Mathias RS. Hypoxia and response of human umbilical artery strips to 5-hydroxytryptamine: role of prostaglandin F-2 alpha. *Gen Pharmacol* 1997; 28 (1):77-83.
17. Fox AJ, Laloo UG, Belvisi MG, Bernareggi M, Chung KF, Barnes PJ. Bradykinin evoked sensitization of airway sensory nerves: a mechanism for ACE-inhibitor cough. *Nat Med* 1996; 2 (7):814-7.
18. Francel PC. Bradykinin and neuronal injury. *J Neurotrauma* 1992; 9 Suppl 1, S27-45.
19. Parpura V, Basarsky TA, Liu F, Jefinija S, Haydon PG. Glutamate-mediated astrocyte-neuron signaling. *Nature* 1994; 369 (6483):744-7.
20. Walker K, Perkins M, Dray A. Kinins and kinin receptors in the nervous system. *Neurochem Int* 1995; 26 (1):1-16.
21. Zausinger S, Lumenta DB, Pruneau D, Schmid-Elsaesser R, Plesnila N, Baethmann A. Effects of LF 16-0687 Ms, a bradykinin B<sub>2</sub> receptor antagonist, on brain edema formation and tissue damage in a rat model of temporary focal cerebral ischemia. *Brain Research* 2002; 950 (1-2): 268-78.
22. Plesnila N, Schulz J, Stoffel M, Eriskat J, Pruneau D, Baethmann A. Role of bradykinin B<sub>2</sub> receptors in the formation of vasogenic brain edema in rats. *J Neurotrauma* 2001; 18 (10): 1049-58.
23. Relton JK, Beckey VE, Hanson WL, Whalley ET. CP-0597, a selective bradykinin B<sub>2</sub> receptor antagonist, inhibits brain injury in a rat model of reversible middle cerebral artery occlusion. *Stroke* 1997; 28: 1430-6.
24. Abbas F, Clayton JK, Marshall M, Senior J. Investigation into the role of cyclooxygenase products in the bradykinin response on isolated human myometrium and umbilical artery. *Immunopharmacology* 1996; 33 (1-3): 123-6.
25. Radenkoviæ M, Grboviæ L, Nebojša Radunoviæ N, Momèilov P. Pharmacological evaluation of bradykinin effect on human umbilical artery in normal, hypertensive and diabetic pregnancy. *Pharmacol Rep* 2007; 59 (1): 64-73.