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(54) **Titre : UTILISATION D'UN BETA-BLOQUANT POUR LA FABRICATION D'UN MEDICAMENT POUR LE TRAITEMENT DES HEMANGIOMES**  
(54) **Title: USE OF A BETA BLOCKER FOR THE MANUFACTURE OF A MEDICAMENT FOR THE TREATMENT OF HEMANGIOMAS**

(57) **Abrégé/Abstract:**

The present invention relates the use of a beta blocker for the manufacture of a medicament for the treatment of hemangiomas, for example of infantile hemangiomas. The beta blocker may be a non-selective beta-blocker, for example propranolol. The present invention provides an alternative to the known compounds, e.g. corticosteroids, interferon or vincristine, generally used for the treatment of hemangiomas.



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(54) Title: USE OF A BETA BLOCKER FOR THE MANUFACTURE OF A MEDICAMENT FOR THE TREATMENT OF HEMANGIOMAS

(57) Abstract: The present invention relates the use of a beta blocker for the manufacture of a medicament for the treatment of hemangiomas, for example of infantile hemangiomas. The beta blocker may be a non-selective beta-blocker, for example propranolol. The present invention provides an alternative to the known compounds, e.g. corticosteroids, interferon or vincristine, generally used for the treatment of hemangiomas.



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**SPECIFICATION****USE OF A BETA BLOCKER FOR THE MANUFACTURE OF A  
MEDICAMENT FOR THE TREATMENT OF HEMANGIOMAS****Technical field**

5           The present invention relates the use of a beta-blocker for the manufacture of a medicament for the treatment of hemangiomas, for example of infantile hemangiomas.

          Also disclosed is a method for the treatment of hemangiomas by using the present invention.

10           In the following text, the bracketed bolded references are references attached to the cited documents and publication also listed in the reference listing after the « Example » part of the specification.

**Prior art**

15           Infantile capillary hemangiomas (IH) Hemangiomas in children are most commonly recognized in the skin and liver. IH Infantile capillary hemangiomas (IH) are the most common soft tissue tumours of infancy, occurring in 4 to 10% of children under 1 year of age as disclosed in Frieden IJ et al, "Infantile hemangiomas: current knowledge, future  
20 directions, Proceedings of a research workshop on infantile hemangiomas", *Pediatr Dermatol* 2005; 22:383-406 [1].

          IH is made of a complex mixture of cell types including a majority of endothelial cells, associated with pericytes, dendritic cells and mast cells. Endothelial cells derived from proliferating hemangiomas are  
25 clonal in origin as disclosed in document [1] and by Bielenberg D.R. et al, "Progressive growth of infantile cutaneous hemangiomas is directly correlated with hyperplasia and angiogenesis of adjacent epidermis and inversely correlated with expression of the endogenous angiogenesis inhibitor", *INF-beta. Int. J. Oncol.*; 14:401-408 [10], Boye E, et al.  
30 Clonality and altered behaviour of endothelial cells from hemangiomas. J

Clin Invest 2001;107:745-52 [9] suggesting that hemangiomas arise from the clonal expansion of an endothelial precursor cell, which might be derived of a haematopoietic stem cell as disclosed in [1].

IH endothelial cells exhibit a distinctive molecular phenotype characterized by immuno-histochemical positivity in document [1]: indoleamine 2,3-dioxygenase (IDO) and LYVE-1 both positive in early phase IH and lost during maturation to a blood vascular phenotype, Glucose transporter 1 (Glut-1), Lewis Y Ag (Le Y), FcR $\gamma$ II, merosin, CCR6, and CD 15.

Regulators of IH growth and involution are still poor understood, but it has been demonstrated that during their growth phase, two major pro-angiogenic factors are involved: basic fibroblast growth factor (bFGF) and vascular endothelial growth factor (VEGF) which are present in situ, but also in blood and urines as disclosed in document [1]. and in Mancini A.J. et al, "Proliferation and apoptosis within juvenile capillary hemangiomas", A.m. J. Dermatopathol. 1996; 18:505-514 [11].

In addition, in situ hybridization for the VEGF receptor (VEGF-R) in proliferative IH has shown that VEGF-Rs are evenly spread throughout the hemangioma and not yet assembled into blood vessels.

During the growth phase of IH, histological studies have showed that both endothelial and interstitial cells are in proliferative state (MIB1 staining strongly positive) as disclosed in Mancini et al. Proliferation and apoptosis within juvenile capillary hemangiomas. Am J Dermatopathol 1996;18:505-14 [10] . and on the other hand during the involution phase the cells exhibit markers of apoptosis as disclosed in [10] and Razon M.J. et al, "Increased apoptosis coincides with onset of involution in infantile hemangioma", Microcirculation 1998; 5:189-195 [11] One hypothesis to explain endothelial cell apoptosis in capillary hemangiomas is the expression of ICAM-1 on the cell surface, but an alternative possibility may be the loss of stimulatory factors such as VEGF [1].

The adrenergic system is the major regulator of cardiac and vascular function. Capillary endothelial cells express beta 2-adrenergic

receptors as disclosed in D'Angelo G. et al, "cAMP-dependant protein kinase inhibits the mitogenic action of vascular endothelial growth factor and fibroblast growth factor in capillary endothelial cells by blocking Raf activation", J. Cell Biochem. 1997; 67:353-366 [13] which modulate the  
5 release of NO, causing endothelium-dependent vasodilatation. In addition, beta-adrenergic receptors belong to the family of G-protein-coupled receptors and when they are activated by adrenergic catecholamines they can promote a series of intracellular signal transduction pathways as disclosed in Iaccarino G, et al. Ischemic  
10 neoangiogenesis enhanced by beta2-adrenergic receptors overexpression: a novel role for the endothelial adrenergic system. Circ Res 2005; 97:1182-1189 [12] and [13]. Beta receptor stimulation can induce modifications of signal transduction pathways of angiogenic factors such as VEGF or bFGF as disclosed in [13]. It has been  
15 demonstrated that the increase of cAMP levels inhibit VEGF-and bFGF-induced endothelial cell proliferation. Pharmacological or beta-adrenergic receptor-mediated elevations in cAMP block mitogen-induced activation of the MAPK signaling pathway leading to blockade of Raf-1 activity via increased PKA activity [13].

20 In addition, it has been demonstrated that betablockade can induce apoptosis of cultured capillary endothelial cells as disclosed in Sommers Smith S.K. et al, "Beta blockade induces apoptosis in cultured capillary endothelial cells", In Vitro Cell Dev. Biol. Anim. 2002; 38:298-304 [14].

25 Despite their benign self-limited course, common IH are rarely responsible during their proliferative phase for local complications such as ulceration or haemorrhage. The so-called alarming HI disclosed for example in Enjolras O. et al. "Management of alarming hemangiomas in  
30 infancy: a review of 25 cases", Pediatrics 1990;85:491-8 [4] can impair vital or sensorial functions especially when present respectively on upper airways and orbital areas.

In addition, IH cause at least transient cosmetic disfigurement which trigger psychological morbidity first in parents and later in affected children as disclosed in document [1] and in Tanner J.L. et al, "Growing up with a facial hemangioma: parent and child coping and adaptation, Pediatrics", 1998; 101:446-452 [2].

Systemic or intralesional corticosteroids are used as first line treatments for problematic lesions during the proliferative phase as disclosed in Bennett ML et al, Oral corticosteroid use is effective for cutaneous hemangiomas, An evidence-based evaluation, Arch. Dermatol. 2001; 137 :1208-13 [3].

However, even at high dosages (2 to 5mg/kg of body weight/day), response rates to treatment range from 30 to 60% as disclosed in documents [1], [3] and [4]. Adverse effects are usually transient and limited such as cushingoid facies, irritability, growth suppression, but may cause more concern hypertrophic cardiomyopathy.

Other treatment options include interferon alfa-2a and 2b (40 to 50% of complete response with dosing 1-3 mU/m<sup>2</sup>/day) (millions of units per m<sup>2</sup>) but a risk of neurotoxicity has been reported in children under 1 year of age, as disclosed in documents [1] and [5]; vincristine is also used for its antimitotic properties as disclosed in document [1] but its well-known downsides are peripheral neuropathy, constipation, and hematologic toxicity.

Further, the new anti-angiogenic factors such as avastatin are contra-indicated in young children because of their side effects.

Moreover, because most patient receiving treatment are infant or small children, patient tolerance for the known compounds becomes of more paramount importance.

Thus, needs exist of alternative, more efficient and less toxic compounds for the treatment of IH, in particular of infantile capillary haemangiomas. The present invention fulfills these and other needs.

## Description of the invention

Propranolol is a well tolerated non-selective beta blocker commonly used in young children for cardiologic indications as disclosed by Villain E et al in Low incidence of cardiac events with beta-blocking therapy in children with long QT syndrome, Eur. Heart J. 2004; 25:1405-11 [6], by Fritz K.I. et al, Effect of beta-blockade on symptomatic dexamethasone-induced hypertrophic obstructive cardiomyopathy in premature infants: three case reports and literature review. J Perinatol 1998; 18:38-44 [7], and by Kilian K. in Hypertension in neonates causes and treatments, J. Perinat Neonatal Nurs. 2003; 17:65-74 [8]. But this beta-blocker and beta-blockers in general have never been experimented nor disclosed for a use in the treatment of haemangiomas.

The present inventors are the first ones to have experimented and observed that beta-blockers may be very efficient to control the growth of IH and even to treat IH. The observations and experimental results are provided in the present application.

Accordingly, in a first aspect, the present invention provides the use of beta blocker for the manufacture of a medicament for the treatment of hemangiomas.

According to one aspect, the present invention relates to the use of a beta blocker in the manufacture of a medicament for the treatment of hemangiomas, wherein the beta-blocker is selected from the group consisting of a non-selective beta blocker and/or a beta-1-selective beta blocker.

According to another aspect, the present invention relates to a propranolol or a pharmaceutical salt thereof for use in the treatment of hemangiomas.

According to still another aspect, the present invention relates to the use of propranolol or a pharmaceutical salt thereof for the treatment of hemangiomas.

According to yet another aspect, the present invention relates to a propranolol or a pharmaceutical salt thereof for use in the manufacture of a medicament for treatment of hemangiomas.

5a

« Beta blocker » refers also herein to beta-receptor blocking agent, beta adrenergic receptor blocking agent, beta blocking agent, beta-blocking agent or beta-adrenergic receptor blocking agent or any other denomination indicating a chemical that inhibits the binding of agonists, natural or artificial, to beta-adrenergic receptors of any type (beta-1 ,  
5 beta-2, beta-3 or others).

According to the present invention, the beta blocker may be a non-selective beta blocker, a beta-1 -selective beta blocker, a mixture of alpha-1/beta-adrenergic antagonists, a beta-2-selective beta blocker. The beta-blocker may also be a mixture of two or more beta-blockers.

10 Examples of beta blocker that may be used in the present invention are disclosed in Goodman and Gilman's the pharmacological basis of therapeutics, eleventh edition, chapter 10, pp 271-295, 2006 [19].

Preferably, according to the present invention, when a non-selective beta blocker is used, it may be selected for example from the group comprising alprenolol, bucindolol, carteolol, carvedilol, labetalol, levobunolol, medroxalol, mepindolol, metipranolol, nadolol, oxprenolol, penbutolol, pindolol, propafenone (propafenone is a sodium channel blocking drug that also is a beta-adrenergic receptor antagonist), propranolol, sotalol, timolol or pharmaceutically acceptable salts thereof, A mixture thereof may be used.

When a beta-1 selective beta blocker is used according to the present invention, it may be selected for example from the group comprising acebutolol, atenolol, betaxolol, bisoprolol, celiprolol, esmolol, metoprolol, nebivolol.

The beta blocker may also have an intrinsic sympathomimetic activity as acebutolol, betaxolol, carteolol, carvedilol, labetalol, oxprenolol, penbutolol, pindolol, propranolol

Preferably, the beta blocker is propranolol or a pharmaceutically salt thereof, for example L or D-propranolol or a mixture thereof. The mixture may be a mixture of L and D-propranolol, with an amount thereof of 0:1 to 1:0, for example 1:1. Pharmaceutically acceptable salt of the propranolol may be propranolol chlorhydrate or any other preparation of propranolol, whether or not the preparation changes or alters the pharmacokinetic properties or metabolism of propranolol.

According to the present invention, the medicament may be a medicament for treating infantile capillary hemangiomas.

According to the present invention, the medicament may also be a medicament for treating other vascular tumors, for example those selected from the group comprising hemangiomas (i.e. epithelioid hemangioma, sinusoidal hemangioma, spindle cell hemangioma), tufted angioma, hemangioendotheliomas (i.e. kaposiform hemangioendothelioma), hemangioma in the von Hippel-Lindau syndrome, angiofibroma and angiolipoma in Bourneville disease, pyogenic granuloma, angiosarcomas, for example Kaposi's sarcoma, expanding arteriovenous malformations, tumor-associated vascular

proliferation. Reference M. Wassef and coll. Vascular tumours and malformations, classification, pathology and imaging. Ann Chir Plast Esth 2006; 51:263-281 [20] discloses anatomopathologic classification of these active proliferation tumors.

5           The medicament may be in any form that can be administered to a human or an animal. Administration may be carried out directly, i.e. pure or substantially pure, or after mixing of the beta-blocker with a pharmaceutically acceptable carrier and/or medium.

10           According to the present invention, the medicament may be a syrup or an injectable solution.

          According to the present invention, the medicament may be a medicament for oral administration selected from the group comprising a liquid formulation, an oral effervescent dosage form, an oral powder, a multiparticule system, an orodispersible dosage form.

15           For example, when the medicament is a medicament for oral administration, it may be in the form of a liquid formulation selected from the group comprising a solution, a syrup, a suspension, an emulsion and oral drops. When the medicament is in the form of an oral effervescent dosage form, it may be in a form selected from the group comprising  
20           tablets, granules, powders. When the medicament is the form of an oral powder or a multiparticulate system, it may be in a form selected from the group comprising beads, granules, mini tablets and micro granules. When the medicament is the form of an orodispersible dosage form, it may be in a form selected from the group comprising orodispersible  
25           tablets, lyophilised wafers, thin films, a chewable tablet, a tablet and a capsule, a medical chewing gum.

          According to the present invention, the medicament may be a medicament for buccal and sublingual routes, for example selected from the group comprising buccal or sublingual tablets, muco adhesive  
30           preparation, lozenges, oro-mucosal drops and sprays.

          According to the present invention, the medicament may be a medicament for topical-transdermal administration, for example selected from the group comprising ointments, cream, gel, lotion, patch and foam.

According to the present invention, the medicament may be a medicament for nasal administration, for example selected from the group comprising nasal drops, nasal spray, nasal powder.

5 According to the present invention, the medicament may be a medicament for rectal administration, for example suppository or hard gelatin capsule.

According to the present invention, the medicament may be a medicament for parenteral administration, for example subcutaneous, intramuscular, intravenous administration.

10 The skilled person in the art understands clearly that the term "form" as used herein refers to the pharmaceutical formulation of the medicament for its practical use. For example, the medicament may be in a form selected from the group comprising an injectable form (for example as Avlocardyl®5mg/ml), syrup (for example as Efferalgan®3%),  
15 oral suspension (for example as Efferalgan®3% ), a pellet (for example as Dafalgan®1g), powder (for example as Doliprane®100mg ), granules (for example as Zoltum®10mg ), spray, transdermal patch (for example as Cordipatch®5mg/24h ) or local form (cream, lotion, collyrium) (for example as Dermoal creme®, as Betneval®lotion and as Chibroxine® collyre  
20 respectively).

In these examples, the beta blocker, for example one of the above-cited beta blockers, for example propranolol, may be added or may replace the active ingredient(s) of said medicaments.

25 The pharmaceutically acceptable carrier may be any known pharmaceutically carrier used for the administration of a beta-blocker to a human or to an animal, depending on the subject. For example, this carrier may be selected from the group comprising for example the monométhoxy-polyéthylène glycol (for example as in Viraferonpeg®) or Liposome (for example as in Ambizome®).

30 The medium may be any known medium used for the administration of a beta-blocker to a human or to an animal. For example, this medium may be selected from the group comprising for example

cremophor (for exemple as in Sandimmun®) or cellulosis (for exemple as in Avlocardyl® LP160mg).

The pharmaceutical form of the drug is selected with regard to the human or animal to be treated. For example, for a child or a baby, a  
5 syrup or an injection is preferred. Administration may be carried out with a weight graduated pipette.

According to the present invention, the medicament may comprise any pharmaceutically acceptable and efficient dose of the beta-blocker to treat hemangiomas. For example, the medicament may  
10 comprise a dose allowing an administration of 1 to 5 mg/kg of body weight per day, for example of 2 to 4 mg/kg of body weight/day.

In a second aspect, the present invention provides a method of treating a subject suffering from hemangiomas is also disclosed. This method comprises the step of administering to said subject a beta-  
15 blocker.

Hemangiomas and beta-blockers, as well as usable formulations are as defined above.

The administration can be made by using any pharmaceutical way known by the skilled person and useful to administrate a beta-  
20 blocker. Examples of administrable forms of medicament are provided above. For example, the administration can be made by direct injection of the beta-blocker. This way of administration, as well as a syrup, is of course preferred for babies.

The administration may be defined so as to allow delivery of a  
25 pharmaceutically acceptable and efficient dose for the treatment of hemangiomas. For example, the administration may comprise a dose of 1 to 5 mg/kg of body weight per day, for example of 2 to 4 mg/kg of body weight/day. The administration may be carried out with one dose or with a plurality of doses per day.

30

The inventors of the present application demonstrate clearly experimentally a strong anti-angiogenic effect in infantile capillary hemangiomas (IH) by the use of a beta-blocker.

Further searches carried out by the present inventors with regard to hemangioma show that adrenergic beta2 receptors are present at the surface of the endothelial cells of hemangioma (see examples below). This confirms the results obtained with the present invention, provides physiopathological explanations and confirms the mechanism of action of beta-blockers in the frame of the present invention. This confirms also the link between efficiency of propranolol and its activity as beta-blocker.

Since the new anti-angiogenic factors of the prior art such as avastatin are contra-indicated in young children because of their side effect, the use of propranolol according to the present invention constitutes a safe alternative to systemic corticosteroids, and even to interferon or vincristine.

Propranolol is a non-selective beta-blocker with weak intrinsic sympathomimetic activity, and its dramatic therapeutic effect on IH could be explained by three mechanisms:

1. a peripheral vasoconstrictor effect inducing cell hypoxia, Propranolol is responsible for peripheral vasoconstriction, and this effect is immediately visible on the IH we have treated.
2. a decreased expression of VEGF and bFGF genes via the down regulation of the Raf/MAPK pathway, or the HIF pathway (Giatromanoloki A, Arvanitidou V, Hatzimichael A, Simopoulos C, Sivridis E [17]. The HIF-2alpha/VEGF pathway activation in cutaneous capillary haemangiomas (Shyu KG, Liou JY, Wang BW, Fang WJ, Chang H. Cardiovedilol prevents cardiac hypertrophy and overexpression of hypoxia-inducible factor-1alpha and vascular endothelial growth factor in pressure-overloaded rat heart. J Biomed Sci. 2005 ; 12 : 409-420[18]).
3. an apoptosis triggering effect on capillary endothelial cells.

In the experimental results disclosed hereunder, a change in color from intense red to purple, associated with a palpable softening of the lesion was observed on babies presented with an IH. This effect could induce a chronic hypoxia of the hemangioma responsible for an arrest of endothelial cell proliferation.

However, in inventor's experimentations, the progressive improvement of IH under propranolol treatment suggests strongly a sustained action on proliferative growth factors.

It is not clear whether in this respect the targets of the treatment are the endothelial cells themselves, or other cells such as interstitial cells or mast cells. The third mechanism possibly involved to explain the involution of IH is an early endothelial cell apoptosis induced by the beta blockade.

However the re-growth of the hemangioma in two of the presented cases, when the treatment was stopped during the proliferative phase of the IH, does not support this hypothesis. In addition, in the second case the inventors did not find apoptotic cell markers by immunohistochemistry using antibodies to cleaved caspases 3 and 8.

Further, the use of beta-blockers is now widespread in neonate or children patients with a good tolerance in cardiac diseases as long QT syndrome as shown in document Villain E. et al, "Low incidence of cardiac events with beta-blocking therapy in children with long QT syndrome", Eur. Heart J. 2004; 25:1405-1411 [6], hypertrophic cardiomyopathie as shown in document Fritz K.I. et al, "Effect of beta-blockade on symptomatic dexamethasone-induced hypertrophic obstructive cardiomyopathy in premature infants: three case reports and literature review", J. Perinatal 1998; 18:38-44 [7] or hypertension as shown in document Kilian K. et al, "Hypertension in neonates causes and treatments", J. Perinat. Neonatal Nurs 2003; 17: 65-74 [8].

This invention is further illustrated by the following examples with regard to the annexed drawings that should not be construed as limiting.

**Brief description of the drawings**

- 5 - Figure 1 is a picture showing the aspect of a hemangioma after 4 weeks of a prior systemic steroids treatment, before beginning of propranolol treatment.
- Figure 2 is a picture showing the aspect of the hemangioma only seven days after onset of propranolol treatment according to the present invention.
- 10 - Figure 3 is a picture showing experimental results at 6 months of age where the child still continues to be treated according to the present invention and prior systemic steroids treatment was stopped since 2 months.
- Figure 4 is a picture showing the experimental results at 9 months of propranolol treatment according to the present invention.
- 15 - Figures 5 is a picture obtained with a method of immunohistochemistry showing that beta2 receptors are expressed on endothelial cells of IH
- Figures 6 is a picture obtained with a method of immunohistochemistry showing that HIF1 alpha (red staining) are  
20 expressed on endothelial cells of IH.

**EXAMPLES****Example 1 : first experiments according to the present invention**

25 A male baby presented with an IH involving the nasal pyramid. At 2 months of age, systemic steroids were introduced because of dyspnea associated with nasal partition and columella necrosis. After a one-month treatment at 3 mg/kg of body weight/day (mg/kg/day] of prednisolone, the hemangioma was stabilized, but nasal necrosis  
30 progressed. Since the infant progressively refused to take prednisolone tablets, we introduced an equivalent dosage of bethamethasone in drops (0,5mg/kg/day). At 4 months of age, the hemangioma had stopped growing and intra nasal ulcerations had healed.

However, the child returned at a control visit with tachycardia at 180 to 200 pulses per minute, associated with a systolic cardiac murmur. A cardiac sonography showed an obstructive hypertrophic myocardiopathy, justifying a decrease of the betamethasone dosage from  
5 3 to 2 mg/kg of body weight /day (mg/kg/day).

We have thus initiated a treatment with a beta-blocker, propranolol (chemical IUPAC name: (2RS)-1-[1-methylethyl)amino]-3(naphtalen-1yloxy)propan-2-ol) at 3 mg/kg/day. Propranolol was administered as a capsule containing commercial propranolol powder. The  
10 day after the onset of propranolol treatment the hemangioma changed in color from intense red to purple, and softened. Betamethasone was replaced by prednisolone which was progressively tapered down and stopped 6 weeks after initiation of propranolol.

Despite the decrease of systemic steroids, the IH still  
15 continued to improve. At age 5 months  $\frac{1}{2}$ , when steroids had been stopped, no rebound in size or coloration of the IH could be noted. At 14 months of age, the child was still under propranolol, and the corticosteroid-induced hypertrophic cardiomyopathy had regressed. The IH was completely flat, with the persistence of only skin telangiectasias  
20 on a yellow-orange dyscolored skin background, and sequels of intranasal and columella necrosis.

### **Example 2 : second experiment according to the present invention**

The second infant, a male triplet, born at 30 weeks, presented  
25 since birth a plaque-like IH involving the entire right upper limb and the right fronto-parietal and superior eyelid areas.

At one month of age a subcutaneous component developed in 3 areas including the superior eyelid, the parotid region and the axillary fold. Because of risk of visual deprivation prednisolone was started at 3  
30 mg/kg/day.

However, after 2 weeks of treatment the situation was not under control and we decided to increase prednisolone at 5 mg/kg/day for 2 weeks.

Despite this regimen the IH continued to enlarge and at 2 months of age eyelid opening was impossible, the right side of the face being deformed by an enormous tumor as shown in annexed figure 1. In addition the axillary fold was occupied by a tumoral IH component measuring clinically 5 cm in diameter.

MRI showed no intra-cerebral anomalies, but revealed that the IH involved extra and intraconal orbital areas and was responsible for exophthalmia. In addition, MRI showed that the parotid IH was in continuity with a compressive intra-cervical component leading to tracheal and oesophageal deviation; the axillary mass measured 26mm x 45mm x 40mm and extended to the right pulmonary apex.

A cardiac sonography showed an increased cardiac output.

The dosage of prednisolone was reduced to 3 mg/kg/day and a treatment with Propranolol, 2 mg/kg/day, according to the present invention, was initiated.

Like in the previous infant (see above example 1), the lesions softened only 12 hours after the onset of propranolol.

Seven days after, spontaneous ocular opening was possible due to a dramatic reduction in size of the subcutaneous component of the hemangioma as shown in the picture presented in annexed figure 2. Parotid and axillary masses were considerably reduced in size.

These unexpected results obtained with the present invention have to be compared with those presented in the picture of annexed figure 1 that shows the aspect of the hemangioma before onset of propranolol treatment and after 4 weeks of a prior art systemic steroids treatment (2 weeks at 3 mg/kg/d and 2 weeks at 5 mg/kg/d).

Prednisolone treatment was progressively tapered down while the IH continued to improve. At 3 months of age a biopsy sample was obtained on the arm, showing a typical IH. Endothelial cells demonstrated poor staining with the monoclonal antibody MIB-1 suggesting a weak proliferative activity for an IH in a young infant.

In order to assess a possible proapoptotic role of propranolol, immuno-histochemical analysis using monoclonal anti-cleaved caspase-3

and 8 antibodies (Ozyme, Saint Quentin en Yvelines, France), was performed but did not demonstrate positive immunostaining [15].

Prednisolone was stopped at 4 months of age, without any rebound, but a 3-day interruption of propranolol treatment was responsible for a mild increase in size of the hemangioma on the superior eyelid and parotidal areas.

Reintroduction of propranolol treatment at 2mg/kg/day was successful after only 24 hours.

At 6 months of age, the eye opening was satisfactory and no major visual impairment was noted, the parotidal and axillary subcutaneous hemangiomatous components were not palpable and the IH had considerably faded on both face and arm.

Figure 3 provides a picture showing these experimental results at 6 months of age where the child still continue to take 2 mg/kg/d of propranolol but systemic steroids were stopped since 2 months. No subcutaneous component of the hemangioma was noted, and the cutaneous component had considerably faded. In addition the child does not suffered of any visual impairment.

At 9 months of age, the treatment was stopped, without any re-growth of the IH as shown in the picture of annexed figure 4.

### **Example 3 : third experimentation according to the present invention**

A baby girl presented with a right periocular IH noted first at 3 weeks of age and localized on the internal canthus. At 2 months of age, the subcutaneous component of the IH extended into the orbit and limited the opening of the superior eyelid.

Doppler ultrasonography showed an IH measuring 32mm in diameter and 12mm in thickness.

After informed consent obtained from the parents, she was treated with propranolol 2 mg/kg/day. Flattening of the lesion was noted in 12 hours, followed by a progressive improvement.

Control ultrasonography, performed 7 days after the onset of propranolol, showed a decrease in size of the IH: 21mm in diameter versus 32mm and 6mm in thickness versus 12mm, without any hemodynamic modifications.

5 Propranolol was stopped after one month, but a novel increase in size of the IH was noted, necessitating the treatment to be resumed.

At 7 months of age the IH was flat and had faded in color, and ultrasonography could not identify any subcutaneous component.

10 Propranolol was stopped at 8 months without any rebound of the hemangioma.

15 Seven other child suffering from hemangiomas have been treated with propranolol and similar results were obtained. No treatment failure has been observed with the present invention. This kind of results were never achieved in the prior art, for example with corticotherapy or interferon.

20 In summary, these examples show clearly that propranolol has a strong anti-angiogenic effect in IH. Since the new anti-angiogenic factors such as avastatin are contra-indicated in young children because of their side effects, propranolol, may constitute a reasonable safe alternative to systemic corticosteroids, and even to interferon or vincristine.

#### **Example 4 : Comments and further experimental results**

25 The inventors have serendipitously observed that propranolol, well tolerated non-selective beta-blocker commonly used in young children for cardiologic indications, can control the growth phase of IH as reported in Léauté-Labrèze C, Dumas de la Roque E, Hubiche T, Boralevi F, Thambo JB. Propranolol for severe hemangiomas of infancy. 30 New Engl J Med 2008, 358; 24:2650-51 [16]. A possible explanation of the skewed sex ratio, and that the activation of the HIF-2alpha pathway and the subsequent overexpression of VEGF by endothelial cells are involved in the pathogenesis of cutaneous capillary haemangiomas

(Giatromanolaki et al, The HIF-2alpha/VEGF pathway activation in cutaneous capillary haemangiomas. Pathology 2005:149-51 [17]). Surprisingly, studying betablockers for the treatment of cardiac hypertrophy, Shyu et al. revealed that cardivedilol reverses both protein and mRNA of HIF-1alpha and VEGF to the baseline values (Shyu et al., Cardiovedilol prevents cardiac hypertrophy and overexpression of hypoxia-inducible factor-1alpha and vascular endothelial growth factor in pressure-overloaded rat heart. J Biomed Sci. 2005 ; 12 :409-420 [18]). Further searches are conducted looking at the angiogenic cascade downstream of beta adrenergic receptors in vivo and in vitro in IH and at possible genetic determinants influencing the IH phenotype.

### **Histology and immunohistochemistry**

Skin biopsy were embedded in paraffin, cut into 5µm sections and stained with hematoxylin-eosin to assess the general morphology. To visualize the presence of alpha2-adrenergic receptor and the level of expression of HIF1-alpha, sections were incubated respectively with monoclonal rabbit anti-human alpha2-adrenergic receptor 1:100 (PA1-20659, ABR, Golden, USA) or monoclonal mouse anti-human HIF1-alpha 1:1000 (ab8366, abcam, Cambridge, UK) overnight at 4°C. As secondary system, we used Envision horseradish peroxidase system (K4002, K4000 Dako, Trappes, France) which enhances staining sensitivity directed against rabbit for alpha2-adrenergic receptor and mouse for HIF1-alpha. Sections were revealed with aminoethylcarbamide (K3461, Dako, Trappes, France) and counterstained with hematoxylin.

Preliminary immunohistochemistry findings showed that beta2 receptors (annexed figure 5) are expressed on endothelial cells of IH. HIF1 alpha ( annexed figure 6) was also expressed on endothelial cells of IH as recently observed.

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**CLAIMS:**

1. Use of a beta blocker in the manufacture of a medicament for the treatment of hemangiomas, wherein the beta-blocker is selected from the group consisting of a non-selective beta blocker and/or a beta-1-selective beta blocker.
- 5 2. The use according to claim 1, wherein the beta-blocker is a non-selective beta blocker.
3. The use according to claim 1, wherein the non-selective beta blocker is selected from the group consisting of propranolol, alprenolol, carteolol, levobunolol, mepindolol, metipranolol, nadolol, oxprenolol, penbutolol, pindolol, sotalol, timolol,  
10 pharmaceutically acceptable salts thereof and mixture thereof.
4. The use according to claim 1 or 2, wherein the beta blocker is a beta-1 selective beta blocker.
5. The use according to claim 1, wherein the beta blocker is selected from the group consisting of carteolol, oxprenolol, penbutolol, pindolol.
- 15 6. The use according to claim 1, wherein the beta blocker is propranolol or a pharmaceutical salt thereof.
7. The use according to any one of claims 1 to 6, wherein the medicament is for treating capillary hemangiomas and/or capillary infantile hemangiomas.
8. The use according to any one of claims 1 to 7, wherein the medicament is a  
20 syrup or an injectable solution.
9. The use according to any one of claims 1 to 7, wherein the medicament is an oral suspension.
10. The use according to any one of claims 1 to 7, wherein the medicament is in a form selected from the group consisting of a pellet, a powder, a granule, a spray, a cream,  
25 a transdermal patch and a collyrium.

11. The use of claim 6, wherein the medicament is for treating infantile capillary hemangiomas.

12. The use of claim 11, wherein the medicament is adapted to deliver between 1 mg/kg and 5 mg/kg per day of the propranolol or pharmaceutical salt thereof.

5 13. The use of claim 11 or 12, wherein the medicament is for oral administration in the form of a liquid formulation.

14. The use of any one of claims 11 to 13, wherein the pharmaceutical salt is propranolol hydrochloride.

10 15. Propranolol or a pharmaceutical salt thereof for use in the treatment of hemangiomas.

16. The propranolol or a pharmaceutical salt thereof for use according to 15 for treating capillary hemangiomas and/or capillary infantile hemangiomas.

17. The propranolol or a pharmaceutical salt thereof for use according to claim 15 or 16, in a syrup or an injectable solution.

15 18. The propranolol or a pharmaceutical salt thereof for use according to claim 15 or 16, in an oral suspension.

19. The propranolol or pharmaceutical salt thereof for use according to claim 15 or 16, in a form selected from the group consisting of a pellet, a powder, a granule, a spray, a cream, a transdermal patch and a collyrium.

20 20. The propranolol or a pharmaceutical salt thereof for use according to claim 15, for treating infantile capillary hemangiomas.

21. The propranolol or a pharmaceutical salt thereof for use according to claim 20, in an amount of 1 mg/kg and 5 mg/kg per day.

25 22. The propranolol or a pharmaceutical salt thereof for use according to claim 20 or 21, for oral administration in the form of a liquid formulation.

23. The propranolol or a pharmaceutical salt thereof for use according to any one of 20 to 22, wherein the pharmaceutical salt is propranolol hydrochloride.

24. Use of propranolol or a pharmaceutical salt thereof for the treatment of hemangiomas.

5 25. The use of 24, for treating capillary hemangiomas and/or capillary infantile hemangiomas.

26. The use of claim 24 or 25, wherein the propranolol or a pharmaceutical salt thereof is in a syrup or an injectable solution.

10 27. The use of claim 24 or 25, wherein the propranolol or a pharmaceutical salt thereof is in an oral suspension.

28. The use of claim 24 or 25, wherein the propranolol or a pharmaceutical salt thereof is in a form selected from the group consisting of a pellet, a powder, a granule, a spray, a cream, a transdermal patch and a collyrium.

29. The use of claim 24, for treating infantile capillary hemangiomas.

15 30. The use of claim 29, wherein the propranolol or a pharmaceutical salt thereof is used in an amount between 1 mg/kg and 5 mg/kg per day.

31. The use of claim 29 or 30, wherein the propranolol or a pharmaceutical salt thereof is for oral administration in the form of a liquid formulation.

20 32. The use of any one of claims 29 to 31, wherein the pharmaceutical salt is propranolol hydrochloride.

33. Propranolol or a pharmaceutical salt thereof for use in the manufacture of a medicament for treatment of hemangiomas.

25 34. The propranolol or a pharmaceutical salt thereof for use according to 33, the medicament being for treating capillary hemangiomas and/or capillary infantile hemangiomas.

35. The propranolol or a pharmaceutical salt thereof for use according to claim 33 or 34, the medicament being a syrup or an injectable solution.

36. The propranolol or a pharmaceutical salt thereof for use according to claim 33 or 34, the medicament being an oral suspension.

5 37. The propranolol or pharmaceutical salt thereof for use according to claim 33 or 34, the medicament being in a form selected from the group consisting of a pellet, a powder, a granule, a spray, a cream, a transdermal patch and a collyrium.

38. The propranolol or a pharmaceutical salt thereof for use according to claim 33, for treating infantile capillary hemangiomas.

10 39. The propranolol or a pharmaceutical salt thereof for use according to claim 38, the medicament being adapted to deliver the propranolol or a pharmaceutical salt thereof in an amount of 1 mg/kg and 5 mg/kg per day.

40. The propranolol or a pharmaceutical salt thereof for use according to claim 38 or 39, the medicament being for oral administration in the form of a liquid formulation.

15 41. The propranolol or a pharmaceutical salt thereof for use according to any one of claims 38 to 40, wherein the pharmaceutical salt is propranolol hydrochloride.



FIGURE 1



FIGURE 2



FIGURE 3



FIGURE 4



FIGURE 5



FIGURE 6