haematologica
the hematology journal

Early Release Paper

Differential modulation of adhesion molecule expression by hydroxycarbamide in human endothelial cells from the micro- and macrocirculation: potential implications in sickle cell disease vaso-occlusive events

by Sandrine Laurance, Pauline Lansiaux, François-Xavier Pellay, Michelle Hauchecorne, Arndt Benecke, Jacques Elion, and Claudine Lapoumeroulie

Haematologica 2010 [Epub ahead of print]

Citation: Laurance S, Lansiaux P, Pellay FX, Hauchecorne M, Benecke A, Elion J, and Lapoumeroulie C. Differential modulation of adhesion molecule expression by hydroxycarbamide in human endothelial cells from the micro- and macrocirculation: potential implications in sickle cell disease vaso-occlusive events. Haematologica. 2010; 95:xxx doi:10.3324/haematol.2010.026740

Haematologica (pISSN: 0390-6078, eISSN: 1592-8721, NLM ID: 0417435, www.haematologica.org) publishes peer-reviewed papers across all areas of experimental and clinical hematology. The journal is owned by the Ferrata Storti Foundation, a non-profit organization, and serves the scientific community with strict adherence to the principles of open access publishing (www.doaj.org). In addition, the journal makes every paper published immediately available in PubMed Central (PMC), the US National Institutes of Health (NIH) free digital archive of biomedical and life sciences journal literature.

DOI: 10.3324/haematol.2010.026740

Differential modulation of adhesion molecule expression by hydroxycarbamide in human endothelial cells from the micro- and macrocirculation: potential implications in sickle cell disease vaso-occlusive events

Sandrine Laurance,[1,2] Pauline Lansiaux,[1,2] François-Xavier Pellay,[3,4]
Michelle Hauchecorne,[1] Arndt Benecke,[3,4] Jacques Elion,[1,2] and Claudine Lapoumeroulie[1,2]

[1]INSERM, UMR_S763, Hôpital Robert Debré, Paris, F-75019; [2]Université Paris Diderot, Faculté de Médecine, Paris, F-75018, France; [3]Institut des Hautes Etudes Scientifiques, Bures sur Yvette, F-91440, France, and [4]CNRS, USR3078, Institut de Recherche Interdisciplinaire; Université de Lille 1, Lille, F-59021 Cedex, France

Correspondence

Claudine Lapouméroulie, INSERM, UMR_S763, Hôpital Robert Debré, 48 boulevard Sérurier, 75019 Paris, France. E-mail: claudine.lapoumeroulie@inserm.fr
Phone: international +33.140031924. Fax: international +33.140031903

Acknowledgments

We thank Prof. J.F. Oury from the Hôpital Robert Debré Maternity, Paris, France, Dr P. Legendre from the Inserm U770, Le Kremlin Bicêtre, France, and Dr. B. Weskler from Cornell University Medical College, NY, USA, for providing umbilical cords, the protocol For vWF gel electrophoresis and TrHBMEC, respectively. We also thank Julien Picot of the Institut National de la Transfusion Sanguine, Paris, France for his help with flow cytometry experiments and analysis.

DOI: 10.3324/haematol.2010.026740

Funding

This work was supported by institutional funding to the INSERM unit 763, and by the ANR 07MRAR-02603 “SCADHESION” grant. SL was a recipient of a doctoral fellowship from the French Ministère de la Recherche et de la Technologie. FXP was supported by the “Nausicaa Combat Sa Leucémie” Association.

Key words: sickle cell disease, adhesion, hydroxycarbamide, vascular endothelial cells.

DOI: 10.3324/haematol.2010.026740

ABSTRACT

Background. All the cellular partners of the vascular system and especially endothelial cells are involved in the pathophysiology of the vasoocclusive crises associated with sickle cell disease. In sickle cell disease, circulating cells adhere abnormally to endothelial cells in a chronic pro-inflammatory context. Hydroxycarbamide is the only drug with demonstrated efficacy to decrease vasoocclusive crises frequency. Here, we investigated the effects of hydroxycarbamide and/or cytokines on the expression of genes related to adhesion events in endothelial cells from three different vascular sites.

Design and Methods. Endothelial cells representative of the macro- (HUVEC) or microcirculation (TrHBMEC and HPMEC) were grown in the presence or absence of hydroxycarbamide and/or cytokines (TNFα and IFNγ). Expression of genes encoding adhesion proteins was analyzed by RQ-PCR, ELISA, flow cytometry, *in situ* ELISA for extracellular matrix proteins, and western blot.

Results. In cells from the microcirculation, expression of *TSP-1*, *vWF*, and *PECAM-1* genes was decreased by hydroxycarbamide and/or cytokine treatment at the mRNA level. In the macrocirculation their expression was unaffected or increased. Hydroxycarbamide significantly decreased vWF incorporated in the TrHBMEC extracellular matrix. *CD36* mRNA was strongly down-regulated by cytokines in HPMEC, the only cell type in which it is expressed. Hydroxycarbamide decreased soluble PECAM-1 in HUVEC supernatants.

Conclusions. Our results highlight the heterogeneity of vascular endothelial cells responses to hydroxycarbamide and/or cytokines depending upon their origin. They also suggest that hydroxycarbamide has an anti-adhesogenic effect on endothelial cells, but by mechanisms which could vary according to their macro- or microcirculation and organ origin.

DOI: 10.3324/haematol.2010.026740

INTRODUCTION

Vasoocclusion is the major clinical feature of sickle cell disease (SCD). It results in acute painful vasoocclusive crises (VOC) and progresses to multiple organ failure. Vasoocclusion results from the polymerization of deoxyhemoglobin S. However, it is precipitated by complex processes involving multiple cellular and molecular partners. It mostly occurs in the microcirculation (bone marrow, lung, and kidney), although some complications, particularly strokes, involve large vessels. All the cellular components of the blood system are activated in SCD and the endothelium is damaged. This is attested by the presence of circulating endothelial cells, activated monocytes, neutrophils, and platelets, and circulating cytokines in a pro-inflammatory context.(1-4) Furthermore, sickle red blood cells (RBC) are more adhesive than normal.(5) Adhesion events are mediated by (i) membrane-bound receptors at the circulating-cell surface including $\alpha_4\beta_1$ integrin (VLA-4), CD36 (thrombospondin receptor), CD47 (integrin-associated protein), Lu/BCAM (CD239), ICAM-4 and phosphatidylserine (PS) at the RBC surface, L-selectin (CD62L), CD44, α_4 and β_2 integrins, PSGL-1 (P-selectin glycoprotein ligand-1, CD162) and PECAM-1 (CD31) at the leukocyte surface, PSGL-1, P-selectin (CD62P), and the $\alpha_{IIb}\beta3$ and GP1bα glycoproteins at the platelet surface; (ii) membrane-bound counter receptors at the vascular endothelial cell (VEC) surface, including VCAM-1 (CD106), ICAM-1 (CD54), P- and E-selectins (CD62E), $\alpha_v\beta_3$ integrin, Lu/BCAM, CD36 and PECAM-1; (iii) subendothelial matrix elements exposed after VEC injury, including laminin, von Willebrand Factor (vWF), thrombospondin-1 (TSP-1 or THBS1), and fibronectin; and finally (iv) soluble proteins in the plasma, including TSP-1, vWF, fribrinogen, and fibronectin acting as adhesogenic molecules, and also sVCAM-1, sICAM-1, and sP-selectin that act as anti-adhesogens. Taken together, these interactions underlying adhesion events highlight the central role of VEC in the pathogenesis of VOC. Several observations reveal the heterogeneity of VEC.(6-8) In particular, Chi *et al*.

DOI: 10.3324/haematol.2010.026740

established the transcriptomic profiles of 53 cultured VEC types and classified VEC (i) as micro- or macro-VEC, (ii) as arterial or venous VEC, and (iii) according to anatomical localization.(9) Expression of some markers is limited to particular VEC types, e.g. CD36 and vWF are preferentially expressed by VEC of the micro- and the macrocirculation, respectively.(10, 11) Despite the increasingly detailed description of SCD pathophysiology, only one effective drug is presently available, i.e. hydroxycarbamide (HC or hydroxyurea).(12) HC was initially given to SCD patients because it was observed to increase fetal hemoglobin (HbF) in HC-treated patients with myeloproliferative disorders. Increased HbF was expected to be beneficial because HbF interferes with deoxyhemoglobin S polymerization. Indeed, HC-treatment drastically reduces VOC incidence (13) and, in the long term, increased HbF level and decreased VOC frequencies are associated with reduced mortality.(14) However, no short-term correlation could be established between the clinical benefit observed and HbF increase. Indeed, HbF response is highly variable from patient to patient whereas the clinical benefit is almost constant and precedes laboratory changes including HbF increase.(15-17) Guided by this observation, our group and others decided to define more precisely the cellular and molecular targets of HC. In particular, the effects of HC on RBC adhesion and adhesion molecules have been studied. HC decreases the strength of RBC adhesion to VEC, TSP-1 and laminin matrices and also decreases the expression of CD36 and $\alpha_4\beta_1$ integrin at the RBC surface.(18-20) In comparison, data concerning the effects of HC on VEC, the other cellular partner of cell adhesion, are scarce. Adragna et al. reported that HC decreases the adhesion of normal RBC to treated primary VEC from the bovine aorta.(21) As the most frequent site of VOC is bone marrow, we studied the effects of HC on a VEC line derived from the human bone marrow microcirculation, TrHBMEC. Thus, we previously reported that HC modulates VCAM-1 and ICAM-1 expression in TrHBMEC.(22) We also found that HC down-regulates the expression of endothelin-1 (ET-1), a powerful

DOI: 10.3324/haematol.2010.026740

vasoconstrictor, by TrHBMEC and that ET-1 was very rapidly and dramatically decreased in HC treated SCD children, providing an *in vivo* correlate to our *in vitro* observation.(22, 23) These data definitely designate VEC as a HC cellular target.

More recently, we used a transcriptomic approach involving micro-array analysis to exhaustively list HC-target genes in TrHBMEC both at the basal state and in pro-inflammatory conditions and described the effect of HC on the production of pro-inflammatory cytokines by VEC.(24) The aim of the present study was to focus our analysis of the micro-array data on the expression of genes related to adhesion events and to extend our investigation to other human VEC types in order to appreciate how HC and/or cytokines (CY) may modify the adhesogenic patterns of vascular endothelia in different sites. Thus, in addition to TrHBMEC, we studied and compared the effect of HC and/or CY treatments on primary VEC from the lung microcirculation (HPMEC) and from the umbilical vein (HUVEC), the most widely utilized macrocirculation model.

DOI: 10.3324/haematol.2010.026740

DESIGN AND METHODS

Endothelial Cell culture

TrHBMEC were cultured as previously described and used between passage 19 and 23.(25)Human Umbilical Vein Endothelial Cells (HUVEC), primary cells from the macrocirculation, were isolated from umbilical cords as previously described.(26) HUVEC were cultured in Endothelial Cell Growth Medium (PromoCell, Heidelberg, Germany) and used between passage 3 and 7. Human Pulmonary Microcirculation Endothelial Cells (HPMEC), primary cells, were cultured according to the manufacturer's instructions (PromoCell) and used between passage 3 and 7. Cells were grown until 90% of confluence and then exposed to HC treatment with or without TNFα and IFNγ treatment (27) for 24 and 48h for microarray experiments and for 5h, 10h, 16h, 24h and 48h for RQ-PCR experiments and protein assays. HC (Sigma-Aldrich, St Louis, USA) was used at a final concentration of 250μM and TNFα and IFNγ (R&D systems, Abingdon, UK) were used at 100U/ml each.

Microarray experiments

Microarray experiments with TrHBMEC treated with HC and/or CY for 24h or 48h and data analysis were performed as previously described using an Applied Biosystems 1700 Genome Survey Microarray platform (Applied Biosystems, Forster City, USA).(24) Data were generated using the Human Genome Survey (HGS) arrays (Version 1 and 2) which measure gene expression levels of 29,918 validated human genes. Logarithmic fold-changes were calculated as previously described in an "everyone-against-everyone" scheme. Each subtraction profile (HC *vs* NT and HC+CY *vs* CY both at 24 and 48h) was normalized by the NeONORM method with k=0.2 and P-values determined according to a normal distribution hypothesis of signal intensities using standard ANOVA methods. Among the genes identified

DOI: 10.3324/haematol.2010.026740

as being modulated, analysis was focused on the 1275 genes that GO, Kegg, and PANTHER annotations indicated to be related to adhesion events (Supplementary table 1).

RNA isolation and retro-transcription

Total RNA was extracted from cultured cells using the NucleospinRNAII kit according to the manufacturer's instructions (Macherey-Nagel, Düren, Germany). The RNA samples were reverse transcribed as recommended by the manufacturer (Abgene, Epsom, UK). The mix was incubated for 10 minutes at room temperature and then 15 minutes at 42°C. The synthesized cDNA was kept at -20°C until real-time PCR experiments.

Real-time quantitative PCR experiments (RQ-PCR)

RQ-PCR experiments were carried out on ABI 7300 (Applied Biosystems). The sybrgreen intercalant was used to detect amplification and the Sybrgreen Core Reagent was utilized according to the manufacturer's instructions (Abgene). The final concentration of cDNA was approximately 5ng/µl. The primers were used at 300 nM and designed using the Primer Express Software (Applied Biosystems) (Supplementary Table 2). The TATA box binding protein (TBP) gene was used for normalization of the quantitative data because its expression appears stable in our cell systems and TBP primers designed by Bièche et al were used. (28) All RQ-PCR results are expressed as means±SD of percent of expression of the control value for five independent experiments each in duplicate. Values for non-treated cells (NT) served as control values for HC- or CY-treated cells, and those for CY-treated cells for HC+CY-treated cells.

Soluble protein quantification in cell supernatant by ELISA

DOI: 10.3324/haematol.2010.026740

The concentrations of TSP-1, vWF, and soluble PECAM-1 in cell supernatants were evaluated by ELISA. Supernatants were collected after treatment, spun for 10 minutes at 4000g and then stored in several aliquots at -20°C until protein quantification. A commercial kit was used for sPECAM-1 assays according to the manufacturer's instructions (Diaclone, Besançon, France). TSP-1 was assayed as previously described.(29) vWF assays were performed according to the manufacturer's instructions (Dakocytomation, Glostrup, Denmark), and the standard curve was generated by serial dilution of purified vWF (Diagnostica Stago, Asnières, France). All ELISA results are expressed as the mean concentration in pg/ml or ng/ml for five independent experiments each in duplicate.

In situ quantification of extracellular matrix (ECM) proteins by ELISA

VEC were seeded (2 x 10^4 cells in 100 µl) onto 96-well plate in their respective medium 24h before exposition to HC treatment with or without TNFα and IFNγ treatment for 24 and 48h. Plates were washed with PBS 1X without Ca^{2+} and Mg^{2+} and confluent endothelial cell monolayers were lyzed by incubation with 100 µl of a lysis solution containing 0.1% (v/v) Triton X-100, 0.1 M NH_4OH, 1 mM PMSF (phenylmethylsulfonyl fluoride) (Fluka, Sigma-Aldrich), 1X PIC (Protease Inhibitor Cocktail, Sigma-Aldrich) for 20min at RT.(30) ECM were washed three times with PBS 1X, and directly analyzed by *in situ* ELISA. vWF and TSP-1 quantification in ECM were done using Polyclonal Rabbit Anti-Human von Willebrand Factor/HRP antibody (DakoCytomation, Denmark) and polyclonal rabbit anti-human TSP-1 (Calbiochem, Nottingham, UK), respectively.

Analysis of vWF multimer composition

Analysis of vWF multimers was carried out by SDS-agarose gel electrophoresis, using 2% HGT agarose type VI (Sigma-Aldrich). Gels were poured with running gel buffer between two glass plates (18 x 16 cm) preheated at 50°C and separated by a 0.75 mm thick spacer.

DOI: 10.3324/haematol.2010.026740

Electrophoresis was carried out in a vertical gel unit SE 600 (Hoefer Inc. Holliston, MA, USA) and run in a cold room at 4°C for 21h at 55 V with a gentle stirring of the anode buffer. The protocol was adapted from Raines et al.(31)and Groot et al.(32) After electrophoresis, proteins were transferred from the gel to a PVDF membrane (Bio-Rad, Hercules, CA, USA) by capillary blotting procedure overnight at RT in PBS 1X containing 5% methanol. After protein transfer, the western blot analysis for vWF was carried out using Polyclonal Rabbit Anti-Human Von Willebrand Factor/HRP (1:1000) (DakoCytomation). Multimers were detected using enhanced chemiluminescence (ECL) (GE Healthcare, Buckinghamshire, UK)

mbPECAM-1 flow cytometry analysis

Cells were labeled with a mouse anti-human PECAM-1 IgG (clone WM59, Clinisciences, Montrouge, France) and were analyzed on FACS Calibur flow cytometer (Beckton dinckinson, NJ, USA) which analyses 10,000 cells for the presentation of the specific antigen. The number of copies of the antigen molecule per VEC was estimated from a calibration curve obtained with Qifikit calibration beads (DakoCytomation). For reasons of cell availability, flow cytometry analyses were carried out only with TrHBMEC and HUVEC.

Statistical Analysis

Statistical analyses included the t-Test in Graph Pad Prism Software (GraphPad Software, San Diego, USA). Two groups were considered to be significantly different if the *P* value is less than 0.05.

DOI: 10.3324/haematol.2010.026740

RESULTS

Microarray analysis of adhesion-related gene expression in TrHBMEC

All data from the microarray analysis have been deposited at the Gene Expression Omnibus gene expression data repository (http://www.ncbi.nlm.nih.gov/geo/) (GEO accession number GSE11372). The exhaustive list of HC-target genes modulated in TrHBMEC under basal and pro-inflammatory conditions has been established previously.(24)

Adhesion events are crucial for vasoocclusion. We therefore focused on 1,275 genes related to adhesion (Supplementary Table 1). Under basal conditions, 24h of HC treatment modulated the expression of 53 genes and 48h of treatment modulated the expression of 49 genes (Supplementary Tables 3-4). Fewer genes were modulated by HC in pro-inflammatory conditions than in basal conditions: 33 genes at 24h and 21 genes at 48h (Supplementary Tables 5-6). The modulated genes included several genes encoding for collagen and ADAM (A Disintegrin And Metalloproteinase). For example, expression of *COL1A1* encoding the alpha1 chain of collagen type I was decreased by HC treatment at 24h both in basal and pro-inflammatory conditions (5- and 1.6-fold change in basal and pro-inflammatory conditions, respectively). The metalloproteinase ADAMTS4 was increased by HC whatever the cellular context (basal or pro-inflammatory) and the treatment period (fold changes between 5 and 2). The microarray analysis also indicated that VCAM-1, a key mediator of cell adhesion expressed in pro-inflammatory conditions, was down-regulated by HC treatment at 24h in the presence of CY (Supplementary Table 5); this is in agreement with our previous findings.(22, 24) We then individually assessed the effects of HC on the expression in TrHBMEC, HUVEC, and HPMEC of genes involved in SCD pathophysiology, namely *TSP-1*, *vWF*, *PECAM-1* and *CD36*. *CD36* is expressed in HPMEC but not in TrHBMEC or in HUVEC.(10, 25)

DOI: 10.3324/haematol.2010.026740

Effects of HC and/or CY on the two partners of adhesion: TSP-1 and CD36

HC treatment significantly decreased the amount of *TSP-1* mRNA in TrHBMEC and in HPMEC. In TrHBMEC, the decrease was observed from 10h of HC treatment in basal conditions (58.2±9.5% of the control, $P = 0.0122$) (Figure 1Ai) and 5h of HC treatment in pro-inflammatory conditions (80.7±5.9% of the control, $P = 0.047$) (Figure 1Aii). The maximal decrease was after 24h both in basal and pro-inflammatory conditions (30.8±4.3% of the control, $P < 0.0001$, and 37±6.9% of the control, $P = 0.0006$, respectively) and the expression remained low after 48h (30.80±9.6% of the control, $P = 0.0003$, and 37.6±14.1% of the control, $P = 0.0002$, respectively) (Figure 1Ai-ii). In HPMEC, the amount of *TSP-1* mRNA was significantly decreased by HC at 48h in basal conditions (85.9±2.6% of the control, $P = 0.0077$) and at 24h and 48h in pro-inflammatory conditions (79.06±6.3% of the control, $P = 0.018$ and 80.4±4.9%, $P = 0.037$, respectively) (Figure 1Ai-ii). In TrHBMEC treated with CY alone, the amount of this mRNA was significantly higher than in untreated cells at 5h (145.2±14.9% of the control, $P = 0.0392$) but then decreased progressively with time to 54.8±3.2% of the control ($P = 0.0002$) at 48h (Figure 1Aiii). A slight decrease was also observed in HPMEC but without reaching significance (80.2±10.2% of the control) (Figure 1Aiii). By contrast, CY alone increased *TSP-1* mRNA level in HUVEC to a maximum at 16h (153.9±16.04% of the control, $P = 0.0153$) (Figure 1Aiii). Moreover, HC did not affect *TSP-1* mRNA level in HUVEC in either basal or pro-inflammatory conditions (e.g. 144±20.9% and 108±8.4% of the control, respectively, at 48h) (Figure 1Ai-ii).

At the protein level, TSP-1 concentration was lower in supernatants from TrHBMEC and HUVEC (669±105 ng/ml and 500.4±62 ng/ml respectively, at 48h for NT cells) than in HPMEC supernatants (15,350±1,960 ng/ml) (Figure 1Bi). Concerning the effect of HC, a 20-25% decrease was observed in TrHBMEC supernatants at 48h (669.8±105.5 ng/ml for NT cells *vs* 439±96.99 ng/ml for HC-treated cells) and in HPMEC supernatant (15,350±1,960

DOI: 10.3324/haematol.2010.026740

ng/ml for NT-cells *vs* 12,100±2,226 ng/ml for HC-treated cells) in basal conditions, but these differences did not reach statistical significance (Figure 1Bi-ii). Consistent with the findings for the mRNA, HC treatment did not significantly affect TSP-1 concentration in HUVEC supernatants, whatever the treatment duration, either in basal or pro-inflammatory conditions (Figure 1Bi-ii). CY did not significantly affect TSP-1 protein secretion into the supernatant by any of the three cell types: TrHBMEC (608±87.4 ng/ml), HUVEC (493±91 ng/ml) and HPMEC (14,434±2,045 ng/ml) at 48h.

As TSP-1 is also incorporated in the ECM, *in situ* ECM ELISA was carried out to evaluate TSP-1 quantity in TrHBMEC-generated ECM following HC and/or CY treatment. Neither HC nor CY treatment seems to modify the quantity of TSP-1 in ECM whatever the treatment period (Figure 1Biii).

The *CD36* gene is not expressed in TrHBMEC or in HUVEC.(10, 25) In HPMEC, its mRNA expression was not significantly affected by HC treatment. On the contrary, CY alone provoked a large decrease of *CD36* mRNA level at 24h and 48h (21.1±5.8% of the control, $P < 0.0001$, and 18±4.8% of the control, $P < 0.0001$) (Figure 1Ciii).

Effects of HC and/or CY on vWF

In basal conditions, HC significantly decreased *vWF* mRNA level in TrHBMEC after 16h (68±3.1% of the control, $P < 0.001$) and this decrease remained stable at 24h (55.8±6.8% of the control, $P = 0.0001$) and 48h (65.8±26.1% of the control, $P = 0.042$) (Figure 2Ai). The level of *vWF* mRNA was similarly decreased in TrHBMEC in pro-inflammatory conditions after 24h of HC treatment (67±11.2% of the control, $P = 0.04$), this decrease being greater at 48h of treatment (45.4±22.7% of the control, $P = 0.005$) (Figure 2Aii). In HPMEC, HC did not modulate *vWF* expression in basal conditions (Figure 2Ai), and a small decrease was observed in pro-inflammatory conditions (83.8±6.1% of the control, $P = 0.058$) (Figure 2Aii).

DOI: 10.3324/haematol.2010.026740

By contrast, HC significantly increased the amount of *vWF* mRNA in HUVEC at 24h in basal conditions (155.6±19.39% of the control, $P = 0.045$) (Figure 2Ai), a slight increase is also observed in pro-inflammatory conditions at 24h (135±15%, $P = 0.086$) but without reaching a statistical significance (Figure 2Aii). CY alone did not modulate *vWF* mRNA in HUVEC (Figure 2Aiii) but provoked a transient significant decrease of *vWF* mRNA level in HPMEC at 24h (39.5±2.9% of the control, $P < 0.0001$) and in TrHBMEC at 16h and 24h (76.6±7.7% of the control, $P = 0.0386$ and 60.6±8.3% of the control, $P = 0.0091$, respectively) (Figure 2Aiii).

HC and/or CY did not modulate vWF concentrations in supernatants from the three cell types, whatever the treatment period and the environment (Figure 2Bi-ii). The vWF protein concentration was higher, both in basal and in pro-inflammatory conditions, in HUVEC supernatant than in TrHBMEC and HPMEC supernatants (e.g. the vWF concentration was 342.1±120.8 ng/ml at 48h in basal conditions in HUVEC and 132.4±77.2ng/ml in TrHBMEC and 121.8±12.8 ng/ml in HPMEC) (Figure 2Bi).

As for TSP-1, *in situ* ECM ELISA was processed to quantify vWF in TrHBMEC and HPMEC matrix. HC treatment significantly decreased vWF quantity incorporated in TrHBMEC ECM at 48h in basal conditions (3.8±0.5 ng/cm² for NT and 2.1±0.2 for HC-treated cells, $P = 0.0051$) (Figure 2Biii). vWF quantity incorporated in HPMEC MEC was not significantly affected whatever the treatment and the treatment period (Figure 2Biii-iv).

vWF ultralarge multimers (UL-vWF) are the most hemostatically active. Analysis of the vWF multimer pattern was conducted in the supernatants of TrHBMEC, HUVEC, and HPMEC to test for a potential HC impact on vWF multimer generation. Results in Figure 3 compare the multimer patterns in the three cell types of NT and HC-treated cells at 48h in basal conditions. HC did not seem to modify vWF multimer patterns in the three cell types. However, interestingly, the patterns were clearly different between the three cell types. HUVEC

DOI: 10.3324/haematol.2010.026740

excreted UL-vWF, but TrHBMEC and HPMEC presented profiles mostly composed of L-vWF and M-vWF multimers with only small amounts of UL-vWF. Profiles were identical in inflammatory conditions (data not shown).

Effects of HC and/or CY on PECAM-1

In basal conditions, *PECAM-1* mRNA was strongly down-regulated within 5h of HC treatment in TrHBMEC (80.7±5.1% of the control, $P = 0.0049$) and continued to decline at 24h (55.8±9.5% of the control, $P = 0.0098$) and 48h (61±8.4% of the control, $P = 0.01$) (Figure 4Ai). In basal conditions, HC did not modulate *PECAM-1* mRNA level in HUVEC or HPMEC (Figure 4Ai). In inflammatory conditions, the decreased expression of *PECAM-1* mRNA in TrHBMEC was delayed as compared to basal conditions: the decrease was observed from 24h of HC treatment (80.7±5.2% of the control, $P = 0.0082$), and was greater at 48h of treatment (56.6±23.7% of the control, $P = 0.015$) (Figure 4Aii). In these pro-inflammatory conditions, *PECAM-1* mRNA level in HUVEC was not affected by HC treatment but a small decrease was observed in HPMEC at 48h (82.7± 5.1% of the control, $P = 0.04$) (Figure 4Aii). Treatment with pro-inflammatory CY alone did not significantly affect *PECAM-1* mRNA in HUVEC but transiently decreased its level in HPMEC at 24h (52.4±6.5% of the control, $P = 0.0019$) and in TrHBMEC from 5h (76.8±3.5% of the control, $P = 0.0027$) to 24h (52.2±7.5% of the control, $P= 0.0032$) (Figure 4Aiii).

As PECAM-1 is a transmembrane protein, we investigated the effect of HC on PECAM-1 expression on the surface of TrHBMEC and HUVEC by flow cytometry. HC and/or CY did not affect either the numbers of positive cells or the numbers of sites per cell for whichever VEC type, irrespective of treatment duration (data not shown).

The soluble form of PECAM-1 (sPECAM-1) was not detected in TrHBMEC or HPMEC supernatants. But sPECAM-1 was detected in HUVEC supernatants after 24h of culture and

DOI: 10.3324/haematol.2010.026740

its concentration was significantly diminished after 48h of HC treatment in basal conditions (704.6±6 pg/ml for NT cells and 633.4±11.7 pg/ml for HC-treated cells, $P = 0.0006$) (Figure 4Bi). CY alone provoked a small decrease of the sPECAM-1 concentration in HUVEC supernatants after 24h of treatment: 560±10.4 pg/ml for NT and 514±11.6 pg/ml for CY-treated cells, $P = 0.01$ (Figure 4Bi-ii).

DOI: 10.3324/haematol.2010.026740

DISCUSSION

This study is the first in which a global approach (microarray analysis) has been used to investigate the effect of HC and/or CY on the expression of genes related to adhesion events in VEC. In addition, the expression of genes of interest, as inferred from this approach, was then tested individually on VEC models of the microcirculation that are specifically relevant to SCD and VOC, i.e. the TrHBMEC cell line and primary cultures of HPMEC. This was done in comparison with HUVEC, the most widely utilized macrocirculation model.

In our microcirculation models, TrHBMEC and HPMEC, HC reduced the expression of TSP-1, vWF, and PECAM-1 encoding genes at the mRNA level. TSP-1 is synthesized and secreted by VEC and circulating cells such as platelets and monocytes. This multifunctional adhesive protein is present in soluble form in the plasma (sTSP-1) and in the VEC basement membrane. These two forms play an important role in the increased RBC adhesion to the endothelium and the subendothelial matrix. Indeed, the concentration of sTSP-1 is higher than normal in SCD patient plasma, implicating this factor in vasoocclusive events.(33) It has been shown also that sickle RBC adhere to immobilized TSP-1 under flow conditions.(34) We observed a slight but consistent decrease of sTSP-1 in TrHBMEC and HPMEC supernatants. However, it did not reach statistical significance and thus did not match the clear results observed at the mRNA level. Similarly, we did not find statistically significant differences in the TSP-1 ECM content. A protein effect is obviously delayed versus the mRNA effect and it is possible that a 48h treatment was insufficient to observe a significant difference at the protein level. However, longer incubations with HC are not possible because of the drug toxicity; cells are not viable passed this period of time.

Hillery et al. described decreased adhesiveness to TSP-1 of RBC from sickle patients treated with HC.(18) This raises the issue of TSP-1 receptors, including the first to be described, i.e. CD36. Soluble TSP-1 connects two CD36 molecules on the sickle RBC and VEC,

DOI: 10.3324/haematol.2010.026740

respectively. Several studies have shown that HC decreases CD36 expression on sickle RBC membranes.(18, 19) In HPMEC, the only cell type in which the *CD36* gene was expressed in our study, its expression was not affected by HC, but strongly inhibited by CY. Actually, the contribution of CD36 in vasoocclusive events is controversial. Lee et al. reported that the clinical course of CD36-deficient SCD patients is similar to that of CD36-positive SCD patients, suggesting that CD36 does not play a crucial role in vasoocclusion.(35) However, Trinh-Trang-Tan et al., using sickle cell SAD mice, showed recently that erythrocyte CD36 contributes to the increased SAD RBC adhesion, while endothelial CD36 is not indispensable.(36) The issue is complex because CD36 is less strongly expressed on RBC from SAD than wild-type mice. Thus a potential CY-induced decrease of CD36 at the surface of HPMEC might not directly correlate with decreased adhesive properties in inflammatory conditions. In platelets, the phosphorylation state of CD36 dictates its ligand specificity and only dephosphorylated CD36 binds TSP-1.(37) Thus, phosphorylation, another level of regulation of the TSP-1/CD36 adhesion processes in SCD, should be considered in addition to the expression level. Another TSP-1 receptor on RBC is CD47 (or IAP, integrin-associated protein).(38) Unexpectedly, Odièvre et al. described an increase of CD47 at the RBC surface in SCD patients treated with HC.(19) However, here again, the situation is complex because the main involvement of CD47 in adhesion events might not be through its direct interaction with subendothelial TSP-1 but as an intermediate of a signaling pathway in which plasma TSP-1 binding to CD47 initiates a G-protein-PKA-dependent cascade leading to the activating phosphorylation of the $\alpha_4\beta_1$ integrin.(39) Thus it can be expected that even a modest decrease of sTSP-1 under HC treatment, which would be coherent with our results, may lead to significant variations in the number of adhesion events between RBC and VEC.

Concerning the effect of inflammation mediators, expression of the *TSP-1* gene was decreased by CY treatment (TNFα and IFNγ). Previous findings concerning the effects of

DOI: 10.3324/haematol.2010.026740

TNFα on TSP-1 level are controversial;(40, 41) IFNγ seems to increase TSP-1 expression in monocytes.(42) Thus, the increased plasmatic TSP-1 concentration observed in SCD patients is probably not a direct result of increased levels of TNFα on VEC but may be the consequence of multi-cellular and multi-molecular signals. In our study, *CD36* mRNA expression was strongly decreased by CY treatment in HPMEC. In previous studies, CY did not alter CD36 expression modulation in monocytes and CD36 expression was not induced in HUVEC after treatment by TNFα or IFNγ.(10, 42)

Like TSP-1, vWF may promote RBC adhesion, and this may be particularly true for unusually large vWF multimers (ULvWF) which are the most hemostatically active.(43, 44) TSP-1 and vWF show partially related functions, the most important one being the TSP-1 role in ADAMTS13 operated vWF multimer processing.(45) Like platelets, RBC adhere to VEC exposing vWF at high shear stress.(44, 46) As a constituent of the subendothelial matrix, vWF can also promote adhesion between circulating cells and a damaged vessel wall. Our data show that HC down-regulates *vWF* gene expression by VEC from the microcirculation (HPMEC and TrHBMEC). This was not accompanied by a decrease of soluble vWF in the cell supernatant, or changes in the vWF multimer profile. However, we observed a marked decrease of vWF in the ECM of HC-treated TrHBMEC at 24h in basal conditions. This down-regulation of vWF by HC may contribute significantly to the reduction of adhesion events.

We found that HC decreases *PECAM-1* mRNA level in TrHBMEC, but it did not affect protein expression at the cell surface; sPECAM-1 was undetectable in the supernatant of the two microcirculation cells types tested whatever the conditions. A different effect was observed in HUVEC from the macrocirculation: although HC did not affect *PECAM-1* mRNA or its expression at the cell surface, it reduced significantly sPECAM-1 in the cell supernatant. PECAM-1 is a multifunctional molecule that plays a key role in inflammation and vascular biology.(47) It has been implicated in adhesion events and specifically in

DOI: 10.3324/haematol.2010.026740

leukocyte/monocyte transmigration during inflammation processes. Incubation of sickle RBC with HUVEC induces monocyte extravasation.(48) PECAM-1 plays an important role in ischemia/reperfusion injury and increased sPECAM-1 levels have been reported in patients with acute ischemic stroke.(49) The current data suggest that PECAM-1 blockade can be protective in numerous animal models of ischemia/reperfusion injury. Thus our observation that HC reduces sPECAM-1 produced in an endothelial cell model from the macrocirculation may suggest a potential beneficial effect of HC for stroke prevention in SCD patients. This would comfort on-going randomized trials addressing the role of HC in the prevention of large vessel cerebral disease (50) However, the issue cannot be pictured at the protein level only because the adhesion function of PECAM-1 is activated by phosphorylation mediated by the PKC pathway.(51)

Altogether, our gene expression results suggest an anti-adhesogenic effect of HC on VEC, but by different mechanisms depending upon the VEC type. For instance, at the protein level HC decreases vWF in TrHBMEC ECM and sPECAM-1 in HUVEC supernatant. Still, this hypothesis remains to be tested at the functional level. One has also to keep in mind the importance of posttranslational phosphorylation-mediated regulation of the adhesion properties of some of adhesion molecules. In this context, of particular interest is the recent observation by Bartolucci et al (52) that the decreased RBC adhesion to laminin in SCD patients treated with HC is associated with inhibition of erythroid Lu/BCAM protein phosphorylation. Thus, it is clear that in the future, analysis of HC action on adhesion processes should no longer be restricted to the sole mRNA/protein levels.

Finally, our analysis of microarray data indicated that the expression of genes encoding several collagens and metalloproteases was modulated by HC and/or CY. Together with our observation of the modified expression of vWF in ECM, this is possibly suggestive of altered

DOI: 10.3324/haematol.2010.026740

remodeling of the subendothelial matrix and thus be relevant in the context of the systemic vasculopathy associated with SCD.

In conclusion, our analysis shows that variations in the expression profile of genes related to adhesion events in response to HC and/or CY treatment differ between VEC of different origins. This differential response to the same stimuli is consistent with the substantial heterogeneity of VEC notably exemplified by Chi et al. at the transcriptomic level. (9) Similarly, it illustrates, on novel markers, the heterogeneity of VEC responsiveness to CY, an issue of important pharmacological consequences in many diseases involving inflammatory processes.(53) Consequently, HC exact mode of action and efficacy, as well as response to inflammatory stress, in SCD patients, may differ according to the vascular site.

Authorship and Disclosures

SL performed microarray, RQ-PCR, flow cytometry and ELISA experiments, analyzed results, and wrote the manuscript. PL and MH contributed to RQ-PCR and ELISA experiments. FXP and AB performed microarray data and pathway analysis. JE contributed to the design of the research and critically reviewed the results and the manuscript. CL contributed to HPMEC study, *in situ* extracellular matrix ELISA, vWF multimers electrophoresis (together with MH), analysis of the results, and writing of the manuscript.

DOI: 10.3324/haematol.2010.026740

REFERENCES

1. Solovey A, Lin Y, Browne P, Choong S, Wayner E, Hebbel RP. Circulating activated endothelial cells in sickle cell anemia. N Engl J Med. 1997;337(22):1584-90.
2. Belcher JD, Marker PH, Weber JP, Hebbel RP, Vercellotti GM. Activated monocytes in sickle cell disease: potential role in the activation of vascular endothelium and vaso-occlusion. Blood. 2000;96(7):2451-9.
3. Wun T, Cordoba M, Rangaswami A, Cheung AW, Paglieroni T. Activated monocytes and platelet-monocyte aggregates in patients with sickle cell disease. Clin Lab Haematol. 2002;24(2):81-8.
4. Croizat H. Circulating cytokines in sickle cell patients during steady state. Br J Haematol. 1994;87(3):592-7.
5. Cartron JP, Elion J. Erythroid adhesion molecules in sickle cell disease: effect of hydroxyurea. Transfus Clin Biol. 2008;15(1-2):39-50.
6. Lawson ND, Scheer N, Pham VN, Kim CH, Chitnis AB, Campos-Ortega JA, et al. Notch signaling is required for arterial-venous differentiation during embryonic vascular development. Development. 2001;128(19):3675-83.
7. Aird WC. Phenotypic heterogeneity of the endothelium: I. Structure, function, and mechanisms. Circ Res. 2007;100(2):158-73.
8. Aird WC. Phenotypic heterogeneity of the endothelium: II. Representative vascular beds. Circ Res. 2007;100(2):174-90.
9. Chi JT, Chang HY, Haraldsen G, Jahnsen FL, Troyanskaya OG, Chang DS, et al. Endothelial cell diversity revealed by global expression profiling. Proc Natl Acad Sci U S A. 2003;100(19):10623-8.
10. Swerlick RA, Lee KH, Wick TM, Lawley TJ. Human dermal microvascular endothelial but not human umbilical vein endothelial cells express CD36 in vivo and in vitro. J Immunol. 1992;148(1):78-83.
11. Muller AM, Hermanns MI, Skrzynski C, Nesslinger M, Muller KM, Kirkpatrick CJ. Expression of the endothelial markers PECAM-1, vWf, and CD34 in vivo and in vitro. Exp Mol Pathol. 2002;72(3):221-9.
12. Brawley OW, Cornelius LJ, Edwards LR, Gamble VN, Green BL, Inturrisi CE, et al. NIH consensus development statement on hydroxyurea treatment for sickle cell disease. NIH Consens State Sci Statements. 2008;25(1):1-30.
13. Charache S, Terrin ML, Moore RD, Dover GJ, Barton FB, Eckert SV, et al. Effect of hydroxyurea on the frequency of painful crises in sickle cell anemia. Investigators of the Multicenter Study of Hydroxyurea in Sickle Cell Anemia. N Engl J Med. 1995; 332(20):1317-22.
14. Steinberg MH, Barton F, Castro O, Pegelow CH, Ballas SK, Kutlar A, et al. Effect of hydroxyurea on mortality and morbidity in adult sickle cell anemia: risks and benefits up to 9 years of treatment. JAMA. 2003;289(13):1645-51.
15. Maier-Redelsperger M, Labie D, Elion J. Long-term hydroxyurea treatment in young sickle cell patients. Curr Opin Hematol. 1999;6(2):115-20.
16. Ware RE, Eggleston B, Redding-Lallinger R, Wang WC, Smith-Whitley K, Daeschner C, et al. Predictors of fetal hemoglobin response in children with sickle cell anemia receiving hydroxyurea therapy. Blood. 2002;99(1):10-4.
17. Ware RE. How I use hydroxyurea to treat young patients with sickle cell anemia. Blood. 2010;115(26):5300-11.
18. Hillery CA, Du MC, Wang WC, Scott JP. Hydroxyurea therapy decreases the in vitro adhesion of sickle erythrocytes to thrombospondin and laminin. Br J Haematol. 2000; 109(2):322-7.

19. Odievre MH, Bony V, Benkerrou M, Lapoumeroulie C, Alberti C, Ducrocq R, et al. Modulation of erythroid adhesion receptor expression by hydroxyurea in children with sickle cell disease. Haematologica. 2008;93(4):502-10.
20. Styles LA, Lubin B, Vichinsky E, Lawrence S, Hua M, Test S, et al. Decrease of very late activation antigen-4 and CD36 on reticulocytes in sickle cell patients treated with hydroxyurea. Blood. 1997;89(7):2554-9.
21. Adragna NC, Fonseca P, Lauf PK. Hydroxyurea affects cell morphology, cation transport, and red blood cell adhesion in cultured vascular endothelial cells. Blood. 1994; 83(2):553-60.
22. Brun M, Bourdoulous S, Couraud PO, Elion J, Krishnamoorthy R, Lapoumeroulie C. Hydroxyurea downregulates endothelin-1 gene expression and upregulates ICAM-1 gene expression in cultured human endothelial cells. Pharmacogenomics J. 2003;3(4):215-26.
23. Lapoumeroulie C, Benkerrou M, Odievre MH, Ducrocq R, Brun M, Elion J. Decreased plasma endothelin-1 levels in children with sickle cell disease treated with hydroxyurea. Haematologica. 2005;90(3):401-3.
24. Laurance S, Pellay FX, Dossou-Yovo OP, Verger E, Krishnamoorthy R, Lapoumeroulie C, et al. Hydroxycarbamide stimulates the production of proinflammatory cytokines by endothelial cells: relevance to sickle cell disease. Pharmacogenet Genomics. 2010;20(4):257-68.
25. Schweitzer KM, Vicart P, Delouis C, Paulin D, Drager AM, Langenhuijsen MM, et al. Characterization of a newly established human bone marrow endothelial cell line: distinct adhesive properties for hematopoietic progenitors compared with human umbilical vein endothelial cells. Lab Invest. 1997;76(1):25-36.
26. Jaffe EA, Nachman RL, Becker CG, Minick CR. Culture of human endothelial cells derived from umbilical veins. Identification by morphologic and immunologic criteria. J Clin Invest. 1973;52(11):2745-56.
27. De Franceschi L, Bachir D, Galacteros F, Tchernia G, Cynober T, Neuberg D, et al. Oral magnesium pidolate: effects of long-term administration in patients with sickle cell disease. Br J Haematol. 2000;108(2):284-9.
28. Bieche I, Onody P, Laurendeau I, Olivi M, Vidaud D, Lidereau R, et al. Real-time reverse transcription-PCR assay for future management of ERBB2-based clinical applications. Clin Chem. 1999;45(8 Pt 1):1148-56.
29. Poon RT, Chung KK, Cheung ST, Lau CP, Tong SW, Leung KL, et al. Clinical significance of thrombospondin 1 expression in hepatocellular carcinoma. Clin Cancer Res. 2004;10(12 Pt 1):4150-7.
30. Bonnefoy A, Harsfalvi J, Pfliegler G, Fauvel-Lafeve F, Legrand C. The subendothelium of the HMEC-1 cell line supports thrombus formation in the absence of von Willebrand factor and collagen types I, III and VI. Thromb Haemost. 2001;85(3):552-9.
31. Raines G, Aumann H, Sykes S, Street A. Multimeric analysis of von Willebrand factor by molecular sieving electrophoresis in sodium dodecyl sulphate agarose gel. Thromb Res. 1990;60(3):201-12.
32. Groot E, Fijnheer R, Sebastian SA, de Groot PG, Lenting PJ. The active conformation of von Willebrand factor in patients with thrombotic thrombocytopenic purpura in remission. J Thromb Haemost. 2009;7(6):962-9.
33. Browne PV, Mosher DF, Steinberg MH, Hebbel RP. Disturbance of plasma and platelet thrombospondin levels in sickle cell disease. Am J Hematol. 1996;51(4):296-301.
34. Joneckis CC, Shock DD, Cunningham ML, Orringer EP, Parise LV. Glycoprotein IV-independent adhesion of sickle red blood cells to immobilized thrombospondin under flow conditions. Blood. 1996;87(11):4862-70.

35. Lee K, Gane P, Roudot-Thoraval F, Godeau B, Bachir D, Bernaudin F, et al. The nonexpression of CD36 on reticulocytes and mature red blood cells does not modify the clinical course of patients with sickle cell anemia. Blood. 2001;98(4):966-71.
36. Trinh-Trang-Tan MM, Vilela-Lamego C, Picot J, Wautier MP, Cartron JP. Intercellular adhesion molecule-4 and CD36 are implicated in the abnormal adhesiveness of sickle cell SAD mouse erythrocytes to endothelium. Haematologica. 2009;95(5):730-7.
37. Ash AS. Outcomes analysis and the practice of medicine. Hosp Pract (Off Ed). 1993;28(10):10-1.
38. Brittain JE, Mlinar KJ, Anderson CS, Orringer EP, Parise LV. Integrin-associated protein is an adhesion receptor on sickle red blood cells for immobilized thrombospondin. Blood. 2001;97(7):2159-64.
39. Brittain JE, Han J, Ataga KI, Orringer EP, Parise LV. Mechanism of CD47-induced alpha4beta1 integrin activation and adhesion in sickle reticulocytes. J Biol Chem. 2004;279(41):42393-402.
40. Morandi V, Cherradi SE, Lambert S, Fauvel-Lafeve F, Legrand YJ, Legrand C. Proinflammatory cytokines (interleukin-1 beta and tumor necrosis factor-alpha) down regulate synthesis and secretion of thrombospondin by human endothelial cells. J Cell Physiol. 1994;160(2):367-77.
41. Narizhneva NV, Razorenova OV, Podrez EA, Chen J, Chandrasekharan UM, DiCorleto PE, et al. Thrombospondin-1 up-regulates expression of cell adhesion molecules and promotes monocyte binding to endothelium. Faseb J. 2005;19(9):1158-60.
42. Yesner LM, Huh HY, Pearce SF, Silverstein RL. Regulation of monocyte CD36 and thrombospondin-1 expression by soluble mediators. Arterioscler Thromb Vasc Biol. 1996;16(8):1019-25.
43. Kaul DK, Nagel RL, Chen D, Tsai HM. Sickle erythrocyte-endothelial interactions in microcirculation: the role of von Willebrand factor and implications for vasoocclusion. Blood. 1993;81(9):2429-38.
44. Wick TM, Moake JL, Udden MM, Eskin SG, Sears DA, McIntire LV. Unusually large von Willebrand factor multimers increase adhesion of sickle erythrocytes to human endothelial cells under controlled flow. J Clin Invest. 1987;80(3):905-10.
45. Bonnefoy A, Hoylaerts MF. Thrombospondin-1 in von Willebrand factor function. Curr Drug Targets. 2008;9(10):822-32.
46. Andre P, Denis CV, Ware J, Saffaripour S, Hynes RO, Ruggeri ZM, et al. Platelets adhere to and translocate on von Willebrand factor presented by endothelium in stimulated veins. Blood. 2000;96(10):3322-8.
47. Woodfin A, Voisin MB, Nourshargh S. PECAM-1: a multi-functional molecule in inflammation and vascular biology. Arterioscler Thromb Vasc Biol. 2007;27(12):2514-23.
48. Sultana C, Shen Y, Rattan V, Johnson C, Kalra VK. Interaction of sickle erythrocytes with endothelial cells in the presence of endothelial cell conditioned medium induces oxidant stress leading to transendothelial migration of monocytes. Blood. 1998;92(10):3924-35.
49. Zaremba J, Losy J. sPECAM-1 in serum and CSF of acute ischaemic stroke patients. Acta Neurol Scand. 2002;106(5):292-8.
50. Gulbis B, Haberman D, Dufour D, Christophe C, Vermylen C, Kagambega F, et al. Hydroxyurea for sickle cell disease in children and for prevention of cerebrovascular events: the Belgian experience. Blood. 2005;105(7):2685-90.
51. Rattan V, Sultana C, Shen Y, Kalra VK. Oxidant stress-induced transendothelial migration of monocytes is linked to phosphorylation of PECAM-1. Am J Physiol. 1997;273(3 Pt 1):E453-61.

DOI: 10.3324/haematol.2010.026740

52. Bartolucci P, Chaar V, Picot J, Bachir D, Habibi A, Fauroux C, et al. Decreased sickle red blood cell adhesion to laminin by hydroxyurea is associated with inhibition of Lu/BCAM protein phosphorylation. Blood. 2010;116(12):2152-9.
53. Molema G. Heterogeneity in endothelial responsiveness to cytokines, molecular causes, and pharmacological consequences. Semin Thromb Hemost. 2010;36(3):246-64.

Figure 1. Effects of HC and/or Cytokines on TSP-1 and CD36 expression. (A) TSP-1 gene expression was analyzed under HC (i), HC+Cyto (ii) and Cyto (iii) treatment in TrHBMEC (■), HUVEC (▲) and HPMEC (●). Results are expressed as % expression of the control value. (B) TSP-1 protein concentrations in culture supernatants and ECM of TrHBMEC (white bars), HUVEC (grey bars), and HPMEC (dark bars). Results are expressed in ng/ml under HC (i) and HC+Cyto (ii) treatment and in ng/cm² for ECM analysis (iii). (C) Modulation of CD36 gene expression in HPMEC (dark bars) is expressed as % expression of the control value under HC (i), HC+Cyto (ii) and Cyto (iii) treatment. A $\log_2$ scale is used except for ECM analysis. *P<0.05, ** P<0.01, *** P<0.001

Figure 2. Effects of HC and/or Cytokines on vWF mRNA and protein level. (A) *vWF* gene expression under HC (i), HC+Cyto (ii) and Cyto (iii) treatment for TrHBMEC (■), HUVEC (▲) and HPMEC (●). Results are expressed as % expression of the control value and shown on a $\log_2$ scale. (B) vWF protein concentration in cell supernatants and ECM of TrHBMEC (white bars), HUVEC (grey bars), and HPMEC (dark bars). Results are expressed in ng/ml under HC (i), HC+Cyto (ii) for cell supernatant analysis and in ng/cm² under HC (iii), HC+Cyto (iv) for ECM analysis. *P<0.05, ** P<0.01, *** P<0.001

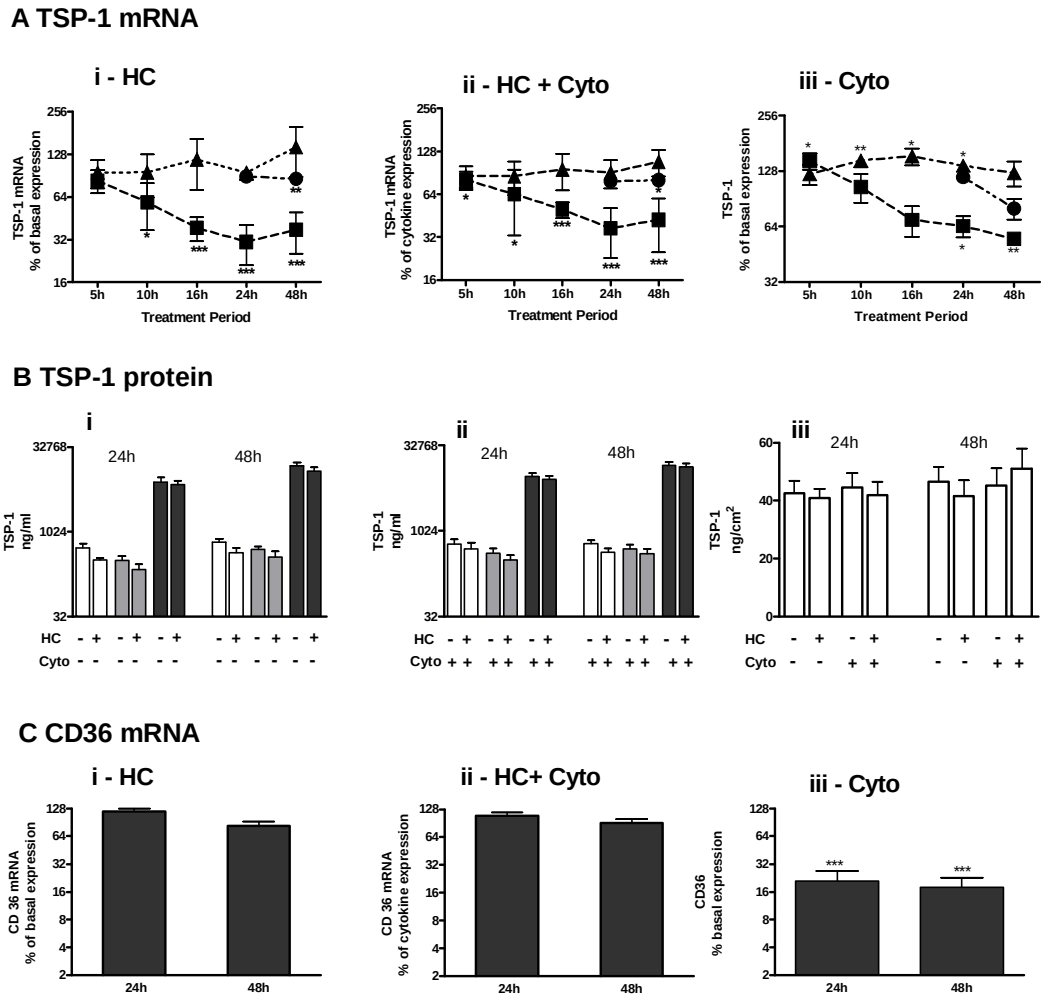
DOI: 10.3324/haematol.2010.026740

Figure 3. vWF multimeric pattern at 48h of treatment. 1: normal plasma, 2: NT TrHBMEC, 3: HC-treated TrHBMEC, 4: NT HUVEC, 5: HC-treated HUVEC, 6: NT-HPMEC and 7: HC-treated HPMEC

Figure 4. Effects of HC and/or Cytokines on PECAM-1 mRNA and protein level. (A) *PECAM-1* gene expression under HC (i), HC+Cyto (ii) and Cyto (iii) treatment in TrHBMEC (■), HUVEC (▲) and HPMEC (●). Results are expressed as % expression of the control value. (B) PECAM-1 protein concentrations in HUVEC supernatant (grey bars) are expressed in pg/ml. A $\log_2$ scale is used. *P<0.05, ** P<0.01, *** P<0.001.

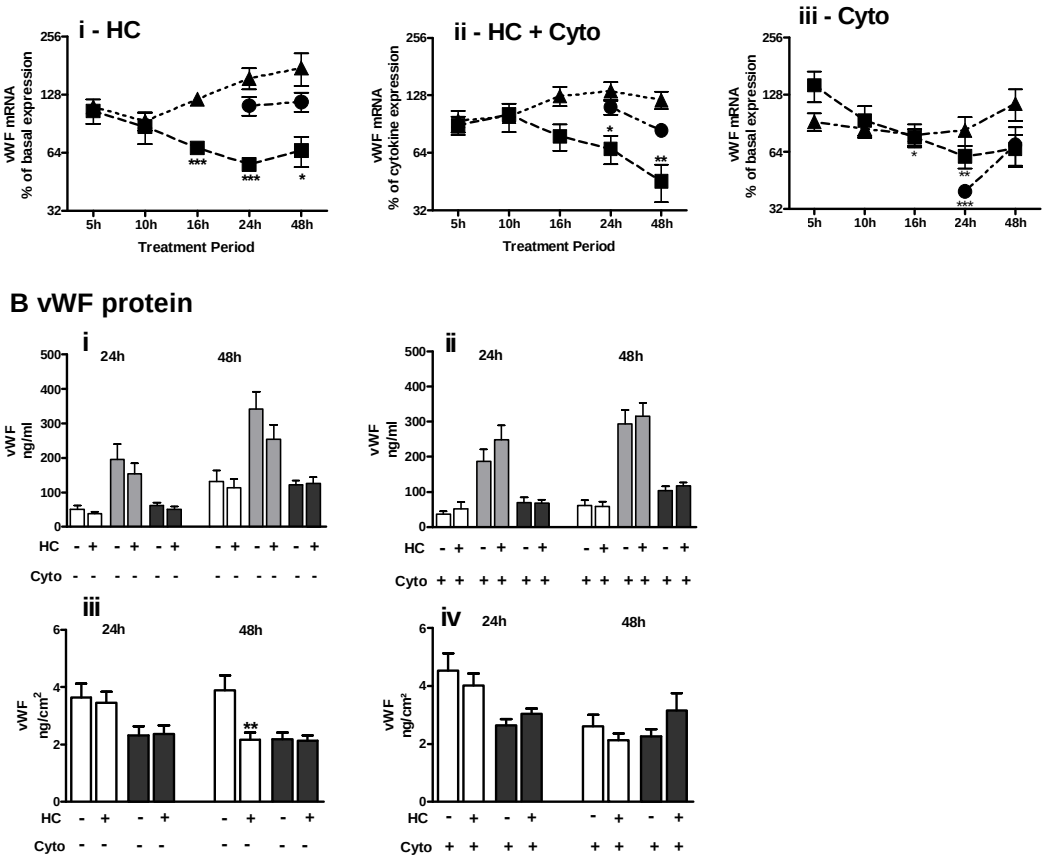
DOI: 10.3324/haematol.2010.026740

Figure 1



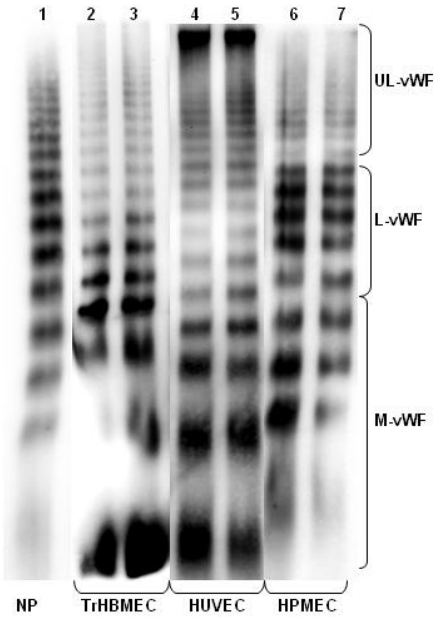
DOI: 10.3324/haematol.2010.026740

Figure 2



DOI: 10.3324/haematol.2010.026740

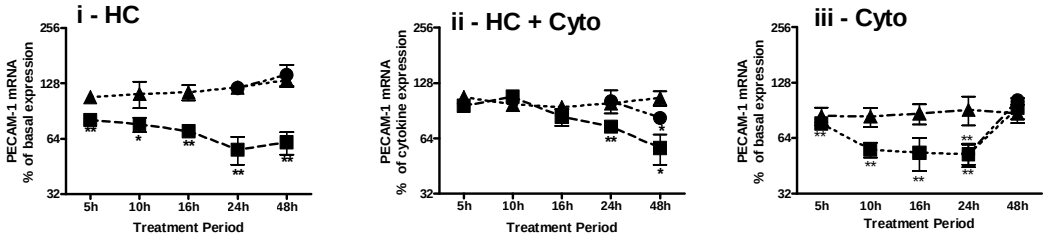
Figure 3



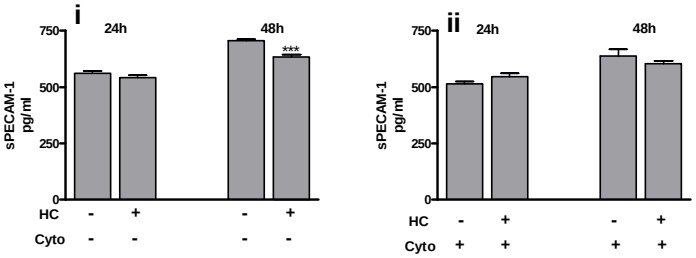
DOI: 10.3324/haematol.2010.026740

Figure 4

A PECAM-1 mRNA



B sPECAM-1



DOI: 10.3324/haematol.2010.026740

Supplementary Table 1: Adhesion genes data set

PROBE	Entrez Gene ID	Celera Gene ID	Gene_Symbol	Gene_Name
160832	1	hCG201364.3	A1BG	alpha-1-B glycoprotein
223658	1	hCG201364.3	A1BG	alpha-1-B glycoprotein
212988	102	hCG40040.3	ADAM10	ADAM metallopeptidase domain 10
133411	4185	hCG28232.2	ADAM11	ADAM metallopeptidase domain 11
110695	8038	hCG40937.4	ADAM12	ADAM metallopeptidase domain 12 (meltrin alpha)
195222	8038	hCG40937.4	ADAM12	ADAM metallopeptidase domain 12 (meltrin alpha)
165344	8751	hCG20021.3	ADAM15	ADAM metallopeptidase domain 15 (metargidin)
189065	6868	null	ADAM17	ADAM metallopeptidase domain 17 (tumor necrosis factor, alpha, converting enzyme)
108119	8728	hCG15398.4	ADAM19	ADAM metallopeptidase domain 19 (meltrin beta)
117763	8748	hCG20675.3	ADAM20	ADAM metallopeptidase domain 20
126448	8747	hCG1785634.2	ADAM21	ADAM metallopeptidase domain 21
208981	8747	hCG1785634.2|hC(	ADAM21	ADAM metallopeptidase domain 21
180903	53616	hCG17212.4	ADAM22	ADAM metallopeptidase domain 22
177272	8745	hCG1811623.1	ADAM23	ADAM metallopeptidase domain 23
102384	10863	hCG1818505.1	ADAM28	ADAM metallopeptidase domain 28
119968	11086	hCG1786734.2	ADAM29	ADAM metallopeptidase domain 29
205542	11085	hCG1997196.1	ADAM30	ADAM metallopeptidase domain 30
148417	80332	hCG39255.4	ADAM33	ADAM metallopeptidase domain 33
140492	8756	hCG1789002.2	ADAM7	ADAM metallopeptidase domain 7
122603	101	hCG1816947.1	ADAM8	ADAM metallopeptidase domain 8
183965	8754	hCG1996391	ADAM9	ADAM metallopeptidase domain 9 (meltrin gamma)
129974	27299	hCG15447.3	ADAMDEC1	ADAM-like, decysin 1
216353	9510	hCG401141.3	ADAMTS1	ADAM metallopeptidase with thrombospondin type 1 motif, 1
135015	81794	hCG23963.2	ADAMTS10	ADAM metallopeptidase with thrombospondin type 1 motif, 10
135934	81792	hCG1812764.1	ADAMTS12	ADAM metallopeptidase with thrombospondin type 1 motif, 12
104172	11093	hCG2033000	ADAMTS13	ADAM metallopeptidase with thrombospondin type 1 motif, 13
173004	11093	hCG2033000	ADAMTS13	ADAM metallopeptidase with thrombospondin type 1 motif, 13
156541	140766	hCG23655.3	ADAMTS14	ADAM metallopeptidase with thrombospondin type 1 motif, 14
139659	170689	hCG40417.2	ADAMTS15	ADAM metallopeptidase with thrombospondin type 1 motif, 15
141688	170690	hCG1811552.1	ADAMTS16	ADAM metallopeptidase with thrombospondin type 1 motif, 16
234856	170690	hCG1811552.1	ADAMTS16	ADAM metallopeptidase with thrombospondin type 1 motif, 16
135701	170691	hCG1993235	ADAMTS17	ADAM metallopeptidase with thrombospondin type 1 motif, 17
179892	170691	hCG1993235	ADAMTS17	ADAM metallopeptidase with thrombospondin type 1 motif, 17
155604	170692	hCG1812188.2	ADAMTS18	ADAM metallopeptidase with thrombospondin type 1 motif, 18
220286	170692	hCG1812188.2	ADAMTS18	ADAM metallopeptidase with thrombospondin type 1 motif, 18
114299	171019	hCG1643514.3	ADAMTS19	ADAM metallopeptidase with thrombospondin type 1 motif, 19
145319	9509	hCG16528.3	ADAMTS2	ADAM metallopeptidase with thrombospondin type 1 motif, 2
224359	9509	hCG16528.3	ADAMTS2	ADAM metallopeptidase with thrombospondin type 1 motif, 2
168207	80070	hCG39495.5	ADAMTS20	ADAM metallopeptidase with thrombospondin type 1 motif, 20
219728	80070	hCG39495.5	ADAMTS20	ADAM metallopeptidase with thrombospondin type 1 motif, 20
227912	80070	null	ADAMTS20	ADAM metallopeptidase with thrombospondin type 1 motif, 20
204346	9508	hCG1811838.1	ADAMTS3	ADAM metallopeptidase with thrombospondin type 1 motif, 3

DOI: 10.3324/haematol.2010.026740

212524	9507	hCG17833.3	ADAMTS4	ADAM metallopeptidase with thrombospondin type 1 motif, 4
136978	11096	hCG401140.3	ADAMTS5	ADAM metallopeptidase with thrombospondin type 1 motif, 5 (aggrecanase-2)
145107	11174	hCG1647431.3	ADAMTS6	ADAM metallopeptidase with thrombospondin type 1 motif, 6
149874	11174	hCG1988853	ADAMTS6	ADAM metallopeptidase with thrombospondin type 1 motif, 6
166404	11174	hCG1811043.3	ADAMTS6	ADAM metallopeptidase with thrombospondin type 1 motif, 6
179622	11174	hCG1647431.3	ADAMTS6	ADAM metallopeptidase with thrombospondin type 1 motif, 6
134341	11173	hCG1640577.3	ADAMTS7	ADAM metallopeptidase with thrombospondin type 1 motif, 7
189195	11173	hCG1640577.3	ADAMTS7	ADAM metallopeptidase with thrombospondin type 1 motif, 7
170995	11095	hCG40418.3	ADAMTS8	ADAM metallopeptidase with thrombospondin type 1 motif, 8
160876	56999	hCG2043003	ADAMTS9	ADAM metallopeptidase with thrombospondin type 1 motif, 9
182644	92949	hCG1818607.2	ADAMTSL1	ADAMTS-like 1
183983	92949	hCG1818607.2	ADAMTSL1	ADAMTS-like 1
227559	92949	hCG1818607.2	ADAMTSL1	ADAMTS-like 1
204050	9719	hCG28143.3	ADAMTSL2	ADAMTS-like 2
158085	57188	hCG27265.3	ADAMTSL3	ADAMTS-like 3
112509	140	hCG1760557.3	ADORA3	adenosine A3 receptor
156250	140	hCG39982.2	ADORA3	adenosine A3 receptor
218175	176	hCG28649.3	AGC1	aggrecan 1 (chondroitin sulfate proteoglycan 1, large aggregating proteoglycan, antigen identified by monoclonal antibody A0122)
122393	177	hCG2044639|hCG2	AGER	advanced glycosylation end product-specific receptor
228903	375790	hCG1995898	AGRN	agrin
186803	197	hCG16147.3	AHSG	alpha-2-HS-glycoprotein
115975	214	hCG27958.2	ALCAM	activated leukocyte cell adhesion molecule
106407	117583	hCG2012035	ALS2CR19	amyotrophic lateral sclerosis 2 (juvenile) chromosome region, candidate 19
224751	117583	hCG2036857	ALS2CR19	amyotrophic lateral sclerosis 2 (juvenile) chromosome region, candidate 19
196021	265	hCG401191.2	AMELX	amelogenin (amelogenesis imperfecta 1, X-linked)
203775	266	hCG1732683.1	AMELY	amelogenin, Y-linked
140620	120425	hCG41155.2	AMICA1	adhesion molecule, interacts with CXADR antigen 1
208102	79658	hCG1811988.1	ARHGAP10	Rho GTPase activating protein 10
136133	23092	hCG1782366.2	ARHGAP26	Rho GTPase activating protein 26
150454	421	hCG17887.4	ARVCF	armadillo repeat gene deletes in velocardiofacial syndrome
228763	421	hCG2002268	ARVCF	armadillo repeat gene deletes in velocardiofacial syndrome
157140	432	hCG1985284	ASGR1	asialoglycoprotein receptor 1
220229	432	hCG1985284	ASGR1	asialoglycoprotein receptor 1
143569	433	hCG32818.4	ASGR2	asialoglycoprotein receptor 2
221995	433	hCG32818.4	ASGR2	asialoglycoprotein receptor 2
105371	54829	hCG1784540.1	ASPN	asporin (LRR class 1)
136536	563	hCG1735841.1|hC(	AZGP1	alpha-2-glycoprotein 1, zinc
111447	63827	hCG17182.3	BCAN	brevican
228373	63827	hCG2042268	BCAN	brevican
171525	633	hCG39567.3	BGN	biglycan
188387	168667	hCG37272.3	BMPER	BMP binding endothelial regulator
228431	168667	hCG2010017	BMPER	BMP binding endothelial regulator
102090	80014	hCG2025762	BOMB	null
118065	80014	hCG2025762	BOMB	null

DOI: 10.3324/haematol.2010.026740

217924	80014	hCG2025762	BOMB	null
234594	80014	hCG2025762	BOMB	null
171578	8927	hCG20124.3	BSN	bassoon (presynaptic cytomatrix protein)
104481	414194	hCG1744837.2	C10orf21	chromosome 10 open reading frame 21
127043	414194	hCG1744837.2	C10orf21	chromosome 10 open reading frame 21
212706	414194	hCG1744837.2	C10orf21	chromosome 10 open reading frame 21
233232	284021	hCG2002349	C17orf60	chromosome 17 open reading frame 60
128389	22918	hCG22367.4	C1QR1	complement component 1, q subcomponent, receptor 1
161637	206938	hCG1818607.2	C9orf94	chromosome 9 open reading frame 94
162273	147372	hCG1980183	CCBE1	collagen and calcium binding EGF domains 1
173022	977	hCG1993428.1	CD151	CD151 antigen
107874	8763	hCG34121.3	CD164	CD164 antigen, sialomucin
157569	388611	hCG19632.2	CD164L2	CD164 sialomucin-like 2
178946	909	hCG1788762.1	CD1A	CD1a antigen
128785	910	hCG39947.3	CD1B	CD1b antigen
150670	911	hCG39946.3	CD1C	CD1C antigen, c polypeptide
198762	912	hCG39945.3	CD1D	CD1D antigen, d polypeptide
193415	913	hCG1640053.3	CD1E	CD1E antigen, e polypeptide
205519	914	hCG39065.3	CD2	CD2 antigen (p50), sheep red blood cell receptor
105368	4345	hCG17791.3	CD200	CD200 antigen
128290	50489	hCG41005.2	CD207	CD207 antigen, langerin
102314	30835	hCG22558.2	CD209	CD209 antigen
170532	10666	hCG17484.3	CD226	CD226 antigen
154682	51744	hCG20847.3	CD244	CD244 natural killer cell receptor 2B4
107703	940	hCG16886.2	CD28	CD28 antigen (Tp44)
164779	11314	hCG29838.3	CD300A	CD300A antigen
204590	10871	hCG1775258.2	CD300C	CD300C antigen
142370	124599	hCG1775263.2	CD300LB	CD300 antigen like family member B
126577	342510	hCG1775271.3	CD300LE	CD300 antigen like family member E
128514	146722	hCG1775264.2	CD300LF	CD300 antigen like family member F
197328	146722	hCG1775264.2	CD300LF	CD300 antigen like family member F
205150	146722	hCG1775264.2	CD300LF	CD300 antigen like family member F
221500	146894	hCG1749090.2	CD300LG	CD300 antigen like family member G
142142	945	null	CD33	CD33 antigen (gp67)
172292	951	hCG16208.4	CD37	CD37 antigen
205264	915	hCG40222.3	CD3D	CD3D antigen, delta polypeptide (TiT3 complex)
126791	916	hCG41147.3	CD3E	CD3E antigen, epsilon polypeptide (TiT3 complex)
214486	917	hCG1646880.3	CD3G	CD3G antigen, gamma polypeptide (TiT3 complex)
211331	920	hCG25949.2	CD4	CD4 antigen (p55)
179899	961	hCG28376.2	CD47	CD47 antigen (Rh-related antigen, integrin-associated signal transducer)
123154	962	hCG20849.3	CD48	CD48 antigen (B-cell membrane protein)
201946	962	hCG20849.3	CD48	CD48 antigen (B-cell membrane protein)
152085	921	hCG40851.2	CD5	CD5 antigen (p56-62)
159670	963	hCG39988.3	CD53	CD53 antigen
152660	923	hCG40393.3	CD6	CD6 antigen

DOI: 10.3324/haematol.2010.026740

148128	924	hCG18659.2	CD7	CD7 antigen (p41)
119574	974	hCG41827.2	CD79B	CD79B antigen (immunoglobulin-associated beta)
186705	941	hCG1780136.3	CD80	CD80 antigen (CD28 antigen ligand 1, B7-1 antigen)
158652	975	hCG15478.3	CD81	CD81 antigen (target of antiproliferative antibody 1)
143954	3732	hCG14702.4	CD82	CD82 antigen
106273	8832	hCG20850.4	CD84	CD84 antigen (leukocyte antigen)
209820	942	hCG14759.4	CD86	CD86 antigen (CD28 antigen ligand 2, B7-2 antigen)
171779	925	hCG34192.4	CD8A	CD8 antigen, alpha polypeptide (p32)
191960	925	hCG34192.4	CD8A	CD8 antigen, alpha polypeptide (p32)
161967	926	hCG2043391|hCG2	CD8B1	CD8 antigen, beta polypeptide 1 (p37)
178355	926	null	CD8B1	CD8 antigen, beta polypeptide 1 (p37)
219372	926	null	CD8B1	CD8 antigen, beta polypeptide 1 (p37)
184793	928	hCG21633.3	CD9	CD9 antigen (p24)
184933	4267	hCG1733152.2	CD99	CD99 antigen
108946	83692	hCG39239.3	CD99L2	CD99 antigen-like 2
130505	999	hCG28201.2	CDH1	cadherin 1, type 1, E-cadherin (epithelial)
198370	1008	hCG36812.4	CDH10	cadherin 10, type 2 (T2-cadherin)
107867	1009	hCG26636.4	CDH11	cadherin 11, type 2, OB-cadherin (osteoblast)
134009	1010	hCG37393.5	CDH12	cadherin 12, type 2 (N-cadherin 2)
187441	1010	hCG37393.5	CDH12	cadherin 12, type 2 (N-cadherin 2)
166999	1012	hCG38474.2	CDH13	cadherin 13, H-cadherin (heart)
145682	1013	hCG32671.3	CDH15	cadherin 15, M-cadherin (myotubule)
146701	1014	hCG28820.3	CDH16	cadherin 16, KSP-cadherin
138781	1015	hCG21654.4	CDH17	cadherin 17, LI cadherin (liver-intestine)
162380	1016	hCG36876.4	CDH18	cadherin 18, type 2
176148	28513	hCG20155.2	CDH19	cadherin 19, type 2
187321	1000	hCG22518.3	CDH2	cadherin 2, type 1, N-cadherin (neuronal)
155649	28316	hCG32902.3	CDH20	cadherin 20, type 2
164226	64405	hCG40018.2	CDH22	cadherin-like 22
131599	64072	hCG2024684	CDH23	cadherin-like 23
221236	64072	hCG2024684	CDH23	cadherin-like 23
161267	64403	hCG2013843.2	CDH24	cadherin-like 24
219069	64403	hCG2013843.2	CDH24	cadherin-like 24
188014	60437	hCG1810933.2	CDH26	cadherin-like 26
222726	60437	hCG1810933.2	CDH26	cadherin-like 26
188051	1001	hCG26655.2	CDH3	cadherin 3, type 1, P-cadherin (placental)
134208	1002	hCG41773.2	CDH4	cadherin 4, type 1, R-cadherin (retinal)
183639	1002	hCG1785839.2	CDH4	cadherin 4, type 1, R-cadherin (retinal)
199571	1002	hCG1821260.1	CDH4	cadherin 4, type 1, R-cadherin (retinal)
122227	1003	hCG26635.3	CDH5	cadherin 5, type 2, VE-cadherin (vascular epithelium)
111907	1004	hCG21458.3	CDH6	cadherin 6, type 2, K-cadherin (fetal kidney)
220675	1004	hCG2003697.1	CDH6	cadherin 6, type 2, K-cadherin (fetal kidney)
147888	1005	hCG32903.3	CDH7	cadherin 7, type 2
190579	1005	hCG32903.3	CDH7	cadherin 7, type 2
156009	1006	hCG1811314.2	CDH8	cadherin 8, type 2

DOI: 10.3324/haematol.2010.026740

112886	50937	hCG39130.2	CDON	Cdon homolog (mouse)
173181	634	hCG21881.4	CEACAM1	carcinoembryonic antigen-related cell adhesion molecule 1 (biliary glycoprotein)
219223	634	hCG21881.4	CEACAM1	carcinoembryonic antigen-related cell adhesion molecule 1 (biliary glycoprotein)
125102	388551	hCG2040706	CEACAM16	carcinoembryonic antigen-related cell adhesion molecule 16
230194	56971	hCG1996183.2	CEACAM19	carcinoembryonic antigen-related cell adhesion molecule 19
133703	125931	hCG22143.3	CEACAM20	carcinoembryonic antigen-related cell adhesion molecule 20
120238	90273	hCG22317.4	CEACAM21	carcinoembryonic antigen-related cell adhesion molecule 21
217645	90273	null	CEACAM21	carcinoembryonic antigen-related cell adhesion molecule 21
187238	1084	hCG22311.4	CEACAM3	carcinoembryonic antigen-related cell adhesion molecule 3
112676	1089	hCG22308.2	CEACAM4	carcinoembryonic antigen-related cell adhesion molecule 4
192350	1048	hCG1642477.2	CEACAM5	carcinoembryonic antigen-related cell adhesion molecule 5
108409	4680	hCG22310.3	CEACAM6	carcinoembryonic antigen-related cell adhesion molecule 6 (non-specific cross reacting antigen)
194623	1087	hCG22307.3	CEACAM7	carcinoembryonic antigen-related cell adhesion molecule 7
197896	1088	hCG21882.3	CEACAM8	carcinoembryonic antigen-related cell adhesion molecule 8
202051	9620	hCG41795.3	CELSR1	cadherin, EGF LAG seven-pass G-type receptor 1 (flamingo homolog, Drosophila)
107531	1952	hCG2036605	CELSR2	cadherin, EGF LAG seven-pass G-type receptor 2 (flamingo homolog, Drosophila)
202001	1951	hCG41177.2	CELSR3	cadherin, EGF LAG seven-pass G-type receptor 3 (flamingo homolog, Drosophila)
162758	116983	hCG1995433	CENTB5	centaurin, beta 5
178907	116983	hCG1995433	CENTB5	centaurin, beta 5
226800	116983	hCG1995433	CENTB5	centaurin, beta 5
185938	1101	hCG29640.3	CHAD	chondroadherin
121311	10752	hCG1994985	CHL1	cell adhesion molecule with homology to L1CAM (close homolog of L1)
209482	10752	hCG1994985	CHL1	cell adhesion molecule with homology to L1CAM (close homolog of L1)
118354	1178	hCG43348.3	CLC	Charcot-Leyden crystal protein
152957	9076	hCG17574.3	CLDN1	claudin 1
129918	9071	hCG2039317|hCG2	CLDN10	claudin 10
155853	5010	hCG18247.3	CLDN11	claudin 11 (oligodendrocyte transmembrane protein)
226478	5010	hCG18247.3	CLDN11	claudin 11 (oligodendrocyte transmembrane protein)
164008	23562	hCG1641900.2	CLDN14	claudin 14
153651	24146	hCG17122.3	CLDN15	claudin 15
182022	24146	hCG17122.3	CLDN15	claudin 15
163630	10686	hCG17572.2	CLDN16	claudin 16
163829	26285	hCG1647580.2	CLDN17	claudin 17
165119	51208	hCG2022628	CLDN18	claudin 18
112697	149461	hCG23165.4	CLDN19	claudin 19
185920	9075	hCG1640071.3	CLDN2	claudin 2
159987	49861	hCG1643100.1	CLDN20	claudin 20
157764	53842	hCG1645805.3	CLDN22	claudin 22
204936	137075	hCG1646163.3	CLDN23	claudin 23
204329	1365	hCG1737329.1	CLDN3	claudin 3
156519	1364	null	CLDN4	claudin 4
234132	1364	hCG1984829	CLDN4	claudin 4
153609	7122	hCG17893.2	CLDN5	claudin 5 (transmembrane protein deleted in velocardiofacial syndrome)
185838	9074	hCG1639991.1	CLDN6	claudin 6
163619	1366	hCG1641357.3	CLDN7	claudin 7

DOI: 10.3324/haematol.2010.026740

185528	9073	hCG1641416.1	CLDN8	claudin 8
179036	9080	hCG1643399.2	CLDN9	claudin 9
234534	9080	hCG1984371	CLDN9	claudin 9
112248	10462	hCG1777068.4	CLEC10A	C-type lectin domain family 10, member A
202592	161198	hCG19714.2	CLEC14A	C-type lectin domain family 14, member A
206625	51266	hCG1773843.2	CLEC1B	C-type lectin domain family 1, member B
130789	10143	hCG1645201.3	CLEC3A	C-type lectin domain family 3, member A
207590	7123	hCG15440.2	CLEC3B	C-type lectin domain family 3, member B
119554	50856	hCG1646296.3	CLEC4A	C-type lectin domain family 4, member A
131983	170482	hCG1821894.2	CLEC4C	C-type lectin domain family 4, member C
147399	338339	hCG1731137.1	CLEC4D	C-type lectin domain family 4, member D
103430	339390	hCG1645989.3	CLEC4G	C-type lectin superfamily 4, member G
180882	10332	hCG22557.3	CLEC4M	C-type lectin domain family 4, member M
118674	93978	null	CLEC6A	C-type lectin domain family 6, member A
113787	283420	hCG1815413.1	CLEC9A	C-type lectin domain family 9, member A
216425	22883	hCG1748747.2	CLSTN1	calsyntenin 1
191167	64084	hCG16061.4	CLSTN2	calsyntenin 2
155501	9746	hCG1811759.1	CLSTN3	calsyntenin 3
198222	9746	hCG1811759.1	CLSTN3	calsyntenin 3
194975	1272	hCG38261.3	CNTN1	contactin 1
170759	6900	hCG16407.3	CNTN2	contactin 2 (axonal)
196546	5067	hCG14804.3	CNTN3	contactin 3 (plasmacytoma associated)
108274	152330	hCG40118.3	CNTN4	contactin 4
199018	152330	hCG40118.3	CNTN4	contactin 4
190701	53942	hCG2032234.1	CNTN5	contactin 5
129580	27255	hCG40124.3	CNTN6	contactin 6
142791	8506	hCG16945.2	CNTNAP1	contactin associated protein 1
112323	26047	hCG15499.4	CNTNAP2	contactin associated protein-like 2
153182	79937|389734	null	CNTNAP3|CNTNAP	contactin associated protein-like 3|contactin associated protein-like 3B
137105	85445	hCG1818591.1	CNTNAP4	contactin associated protein-like 4
224324	85445	hCG1818591.1	CNTNAP4	contactin associated protein-like 4
125999	129684	hCG15059.4	CNTNAP5	contactin associated protein-like 5
222432	129684	hCG15059.4	CNTNAP5	contactin associated protein-like 5
140793	1300	hCG20871.2	COL10A1	collagen, type X, alpha 1(Schmid metaphyseal chondrodysplasia)
172462	1301	hCG32386.2	COL11A1	collagen, type XI, alpha 1
192751	1302	hCG2039805	COL11A2	collagen, type XI, alpha 2
124270	1303	hCG16842.2	COL12A1	collagen, type XII, alpha 1
181713	1305	hCG1787551.2	COL13A1	collagen, type XIII, alpha 1
182265	1305	hCG1787551.2	COL13A1	collagen, type XIII, alpha 1
230401	1305	hCG1787551.2	COL13A1	collagen, type XIII, alpha 1
137206	7373	hCG17879.2	COL14A1	collagen, type XIV, alpha 1 (undulin)
201107	1306	hCG30155.3	COL15A1	collagen, type XV, alpha 1
209753	1307	hCG41613.2	COL16A1	collagen, type XVI, alpha 1
150410	1308	hCG24131.3	COL17A1	collagen, type XVII, alpha 1
141012	80781	hCG1647196.3	COL18A1	collagen, type XVIII, alpha 1

DOI: 10.3324/haematol.2010.026740

110772		1310	hCG15057.2	COL19A1	collagen, type XIX, alpha 1
194003		1277	hCG29609.3	COL1A1	collagen, type I, alpha 1
219504		1277	hCG29609.3	COL1A1	collagen, type I, alpha 1
225487		1277	hCG29609.3	COL1A1	collagen, type I, alpha 1
105493		1278	hCG1686428.3	COL1A2	collagen, type I, alpha 2
184976		57642	hCG23422.2	COL20A1	collagen, type XX, alpha 1
147309		169044	hCG2039138	COL22A1	collagen, type XXII, alpha 1
155672		169044	hCG2039138	COL22A1	collagen, type XXII, alpha 1
221096		169044	hCG2039138	COL22A1	collagen, type XXII, alpha 1
232424		169044	hCG2039138	COL22A1	collagen, type XXII, alpha 1
195072		84570	hCG1778377.2	COL25A1	collagen, type XXV, alpha 1
109131		85301	hCG32517.5	COL27A1	collagen, type XXVII, alpha 1
224496		85301	hCG32517.5	COL27A1	collagen, type XXVII, alpha 1
156790		1280	hCG27706.3	COL2A1	collagen, type II, alpha 1 (primary osteoarthritis, spondyloepiphyseal dysplasia, congenital)
113262		1281	hCG25172.3	COL3A1	collagen, type III, alpha 1 (Ehlers-Danlos syndrome type IV, autosomal dominant)
111306		1284	hCG33042.2	COL4A2	collagen, type IV, alpha 2
191285		1288	hCG1998342	COL4A6	collagen, type IV, alpha 6
110570		1289	hCG2021790	COL5A1	collagen, type V, alpha 1
114784		1290	hCG1776254.2	COL5A2	collagen, type V, alpha 2
181976		50509	hCG28486.2	COL5A3	collagen, type V, alpha 3
215580	1291|5820		hCG401279.2	COL6A1|PVT1	collagen, type VI, alpha 1|Pvt1 oncogene homolog, MYC activator (mouse)
105258		1292	hCG401253.4	COL6A2	collagen, type VI, alpha 2
115643		1293	hCG23027.2	COL6A3	collagen, type VI, alpha 3
154923		1294	hCG41167.3	COL7A1	collagen, type VII, alpha 1 (epidermolysis bullosa, dystrophic, dominant and recessive)
219384		1295	hCG2023566	COL8A1	collagen, type VIII, alpha 1
222934		1295	hCG2023566	COL8A1	collagen, type VIII, alpha 1
202981		1296	hCG1787720.2	COL8A2	collagen, type VIII, alpha 2
109339		1297	hCG1817803.1	COL9A1	collagen, type IX, alpha 1
102661		1298	hCG15675.3	COL9A2	collagen, type IX, alpha 2
176792		1299	hCG23409.3	COL9A3	collagen, type IX, alpha 3
135437		8292	hCG1811147.1	COLQ	collagen-like tail subunit (single strand of homotrimer) of asymmetric acetylcholinesterase
135619	1388|7148		hCG43704.3	CREBL1|TNXB	cAMP responsive element binding protein-like 1|tenascin XB
208454		56253	hCG1646674.2	CRTAM	null
138499	1444|1442|11554		hCG1749481.1	CSHL1|CSH1|FCHO	chorionic somatomammotropin hormone-like 1|chorionic somatomammotropin hormone 1 (placental lactogen)|FCH domain only 2
207524		1462	hCG2015974	CSPG2	chondroitin sulfate proteoglycan 2 (versican)
139135		1463	hCG38558.2	CSPG3	chondroitin sulfate proteoglycan 3 (neurocan)
190250		91353	hCG1776656.2	CTA-246H3.1	null
154907		1490	hCG22108.3	CTGF	connective tissue growth factor
214897		1499	hCG27815.3	CTNNB1	catenin (cadherin-associated protein), beta 1, 88kDa
103069		1500	hCG1811636.1	CTNND1	catenin (cadherin-associated protein), delta 1
217813		1500	hCG1811636.1	CTNND1	catenin (cadherin-associated protein), delta 1
209786		1501	hCG1760222.1	CTNND2	catenin (cadherin-associated protein), delta 2 (neural plakophilin-related arm-repeat protein)
139697		57369	hCG38780.1	CX36	null

DOI: 10.3324/haematol.2010.026740

159867	84694	hCG1646231.2	CX62	null
200724	1605	hCG20125.3	DAG1	dystroglycan 1 (dystrophin-associated glycoprotein 1)
215640	1605	hCG20125.3	DAG1	dystroglycan 1 (dystrophin-associated glycoprotein 1)
166701	160365	hCG38152.3	DCAL1	null
218850	160365	hCG38152.3	DCAL1	null
172487	1630	hCG1811785.1	DCC	deleted in colorectal carcinoma
202024	8642	hCG1814547.2	DCHS1	dachsous 1 (Drosophila)
152068	54798	hCG1744099.2	DCHS2	dachsous 2 (Drosophila)
218176	54798	null	DCHS2	dachsous 2 (Drosophila)
222905	54798	null	DCHS2	dachsous 2 (Drosophila)
226589	54798	hCG1744099.2	DCHS2	dachsous 2 (Drosophila)
186800	149095	hCG20021.3	DCST1	DC-STAMP domain containing 1
173211	780	hCG26003.3	DDR1	discoidin domain receptor family, member 1
158495	4921	hCG14697.3	DDR2	discoidin domain receptor family, member 2
142663	9231	hCG22609.4	DLG5	discs, large homolog 5 (Drosophila)
121544	1758	hCG38539.2	DMP1	dentin matrix acidic phosphoprotein
195445	1805	hCG37801.3	DPT	dermatopontin
211965	1823	hCG25474.3	DSC1	desmocollin 1
201319	1824	hCG24896.3	DSC2	desmocollin 2
104158	1825	hCG2022649	DSC3	desmocollin 3
161543	1826	hCG401236.3	DSCAM	Down syndrome cell adhesion molecule
172677	57453	hCG1810968.1	DSCAML1	Down syndrome cell adhesion molecule like 1
188189	1828	hCG25471.3	DSG1	desmoglein 1
212532	1829	hCG25472.3	DSG2	desmoglein 2
126951	1830	hCG25473.3	DSG3	desmoglein 3 (pemphigus vulgaris antigen)
108789	147409	hCG1811256.3	DSG4	desmoglein 4
101413	1842	hCG31131.3	ECM2	extracellular matrix protein 2, female organ and adipocyte specific
101210	2202	hCG16977.4	EFEMP1	EGF-containing fibulin-like extracellular matrix protein 1
162548	30008	hCG2019682.1	EFEMP2	EGF-containing fibulin-like extracellular matrix protein 2
163870	10278	hCG41733.3	EFS	embryonal Fyn-associated substrate
182179	10278	hCG41733.3	EFS	embryonal Fyn-associated substrate
105515	1953	hCG1810754.1	EGFL3	EGF-like-domain, multiple 3
220221	1953	hCG1810754.1	EGFL3	EGF-like-domain, multiple 3
216444	1955	hCG28560.3	EGFL5	EGF-like-domain, multiple 5
162777	65989	hCG19003.3	EGFL9	EGF-like-domain, multiple 9
187671	2006	hCG18037.3	ELN	elastin (supravalvular aortic stenosis, Williams-Beuren syndrome)
136854	129080	hCG1644096.2	EMID1	EMI domain containing 1
133487	136227	hCG19042.3	EMID2	EMI domain containing 2
165362	11117	hCG23707.4	EMILIN1	elastin microfibril interfacer 1
205983	84034	hCG1646127.2	EMILIN2	elastin microfibril interfacer 2
233100	84034	hCG1995217	EMILIN2	elastin microfibril interfacer 2
114691	90187	hCG1640288.3	EMILIN3	elastin microfibril interfacer 3
203347	10117	hCG17001.3	ENAM	enamelin
133221	90952	hCG39808.2	ESAM	endothelial cell adhesion molecule
182608	50848	hCG20857.3	F11R	F11 receptor

DOI: 10.3324/haematol.2010.026740

131558		2195	hCG16250.2	FAT	FAT tumor suppressor homolog 1 (Drosophila)
111981		2196	hCG1641616.2	FAT2	FAT tumor suppressor homolog 2 (Drosophila)
233727		120114	hCG1642212.3	FAT3	FAT tumor suppressor homolog 3 (Drosophila)
117335		79633	hCG2042809	FAT4	FAT tumor suppressor homolog 4 (Drosophila)
131034		79633	hCG2042809	FAT4	FAT tumor suppressor homolog 4 (Drosophila)
169911		79633	hCG2042809	FAT4	FAT tumor suppressor homolog 4 (Drosophila)
188754		79633	hCG2042809	FAT4	FAT tumor suppressor homolog 4 (Drosophila)
149049		2192	hCG15599.3	FBLN1	fibulin 1
166297		2199	null	FBLN2	fibulin 2
212132		10516	hCG21251.3	FBLN5	fibulin 5
147111		2200	hCG38745.3	FBN1	fibrillin 1 (Marfan syndrome)
124416		2201	hCG1981155	FBN2	fibrillin 2 (congenital contractural arachnodactyly)
160762		84467	hCG1811320.3	FBN3	fibrillin 3
204297		83953	hCG1658516.3	FCAMR	Fc receptor, IgA, IgM, high affinity
129653		2204	hCG20262.3	FCAR	Fc fragment of IgA, receptor for
163064		2204	hCG20262.3	FCAR	Fc fragment of IgA, receptor for
216239		2205	hCG39426.3	FCER1A	Fc fragment of IgE, high affinity I, receptor for; alpha polypeptide
112884		2207	hCG2039142	FCER1G	Fc fragment of IgE, high affinity I, receptor for; gamma polypeptide
153297		2207	hCG2039142	FCER1G	Fc fragment of IgE, high affinity I, receptor for; gamma polypeptide
103950		2208	hCG65710.3	FCER2	Fc fragment of IgE, low affinity II, receptor for (CD23A)
118361		8857	hCG1811266.1	FCGBP	Fc fragment of IgG binding protein
192630		2213	hCG14693.4	FCGR2B	Fc fragment of IgG, low affinity IIb, receptor (CD32)
204612		2213	hCG14693.4	FCGR2B	Fc fragment of IgG, low affinity IIb, receptor (CD32)
127007	9103|2212		null	FCGR2C|FCGR2A	Fc fragment of IgG, low affinity IIa, receptor (CD32)
121117		2217	hCG1998059	FCGRT	Fc fragment of IgG, receptor, transporter, alpha
140760		23149	hCG2000568	FCHO1	FCH domain only 1
168389		115548	hCG1758791.2	FCHO2	FCH domain only 2
123595		2219	null	FCN1	ficolin (collagen/fibrinogen domain containing) 1
120228		2220	hCG18790.3	FCN2	ficolin (collagen/fibrinogen domain containing lectin) 2 (hucolin)
225677		2220	hCG18790.3	FCN2	ficolin (collagen/fibrinogen domain containing lectin) 2 (hucolin)
140258		8547	hCG19629.2	FCN3	ficolin (collagen/fibrinogen domain containing) 3 (Hakata antigen)
205295		115350	hCG39952.3	FCRL1	Fc receptor-like 1
214605		79368	hCG1778713.4	FCRL2	Fc receptor-like 2
227891		79368	hCG1778713.4	FCRL2	Fc receptor-like 2
200756		115352	hCG1775243.3	FCRL3	Fc receptor-like 3
109242		83417	hCG1994902	FCRL4	Fc receptor-like 4
133498		83416	hCG39827.3	FCRL5	Fc receptor-like 5
194394		83416	hCG39827.3	FCRL5	Fc receptor-like 5
110709		84824	hCG1641577.3	FCRLM1	Fc receptor-like and mucin-like 1
173350		127943	hCG1642599.2	FCRLM2	Fc receptor-like and mucin-like 2
148249		2243	hCG1744100.1	FGA	fibrinogen alpha chain
127594		10875	hCG39113.2	FGL2	fibrinogen-like 2
196248		90011	hCG1648275.4	FLJ00060	null
103654		79875	null	FLJ13710	null
151939		79875	hCG1811982.1	FLJ13710	null

DOI: 10.3324/haematol.2010.026740

104533	79978	hCG23580.2	FLJ22814	null
116584	222256	hCG1811544.2	FLJ23834	null
164060	143872	hCG40515.3	FLJ32810	null
209913	143872	hCG40515.3	FLJ32810	null
180026	201633	hCG18876.2	FLJ39873	null
170705	388512	hCG2036612	FLJ45910	null
125618	2331	hCG24329.2	FMOD	fibromodulin
136386	2335	hCG1813428.3	FN1	fibronectin 1
205205	5045	hCG32577.2	FURIN	furin (paired basic amino acid cleaving enzyme)
183719	2697	hCG18153.2	GJA1	gap junction protein, alpha 1, 43kDa (connexin 43)
177186	81025	hCG1786672.2	GJA10	gap junction protein, alpha 10, 59kDa
176726	57165	hCG2036603	GJA12	gap junction protein, alpha 12, 47kDa
175153	2700	hCG20494.1	GJA3	gap junction protein, alpha 3, 46kDa (connexin 46)
202429	2701	hCG37067.2	GJA4	gap junction protein, alpha 4, 37kDa (connexin 37)
173753	2702	hCG1770483.2	GJA5	gap junction protein, alpha 5, 40kDa (connexin 40)
155832	10052	hCG1643215.1	GJA7	gap junction protein, alpha 7, 45kDa (connexin 45)
184298	2703	hCG1646384.3	GJA8	gap junction protein, alpha 8, 50kDa (connexin 50)
104709	2705	hCG19957.2	GJB1	gap junction protein, beta 1, 32kDa (connexin 32, Charcot-Marie-Tooth neuropathy, X-linked)
193823	2706	hCG18943.3	GJB2	gap junction protein, beta 2, 26kDa (connexin 26)
162518	2707	hCG1783754.2	GJB3	gap junction protein, beta 3, 31kDa (connexin 31)
227121	2707	hCG1783754.2	GJB3	gap junction protein, beta 3, 31kDa (connexin 31)
219107	127534	hCG2032177.1	GJB4	gap junction protein, beta 4 (connexin 30.3)
191162	2709	hCG1783753.2	GJB5	gap junction protein, beta 5 (connexin 31.1)
100160	10804	hCG1643047.3	GJB6	gap junction protein, beta 6 (connexin 30)
225135	125111	hCG2007564.1	GJC1	gap junction protein, chi 1, 31.9kDa (connexin 31.9)
228981	349149	hCG2023618	GJE1	gap junction protein, epsilon 1, 29kDa
177639	2812	hCG2002594	GP1BB	glycoprotein Ib (platelet), beta polypeptide
176187	51206	hCG20263.3	GP6	glycoprotein VI (platelet)
112443	2815	hCG18658.2	GP9	glycoprotein IX (platelet)
141331	10223	hCG37989.3	GPA33	glycoprotein A33 (transmembrane)
162415	2817	hCG20534.3	GPC1	glypican 1
128434	221914	hCG2023609	GPC2	glypican 2 (cerebroglycan)
103547	2719	hCG14619.3	GPC3	glypican 3
191994	2239	hCG16065.4	GPC4	glypican 4
108335	2262	hCG32231.4	GPC5	glypican 5
202116	2262	hCG32231.4	GPC5	glypican 5
183836	10082	hCG2039664	GPC6	glypican 6
145583	2995	hCG40440.3	GYPC	glycophorin C (Gerbich blood group)
127294	1404	hCG39210.3	HAPLN1	hyaluronan and proteoglycan link protein 1
149878	60484	hCG1644877.3	HAPLN2	hyaluronan and proteoglycan link protein 2
146996	145864	hCG28642.2	HAPLN3	hyaluronan and proteoglycan link protein 3
147772	404037	hCG2044078|hCG2	HAPLN4	hyaluronan and proteoglycan link protein 4
142523	26762	hCG1647365.2	HAVCR1	hepatitis A virus cellular receptor 1
174455	84868	hCG1782242.3	HAVCR2	hepatitis A virus cellular receptor 2
114296	50863	hCG1811666.1	HNT	null

DOI: 10.3324/haematol.2010.026740

151627	29094	hCG1986781	HSPC159	null
190390	3339	hCG1981506	HSPG2	heparan sulfate proteoglycan 2 (perlecan)
126663	3381	hCG38540.2	IBSP	integrin-binding sialoprotein (bone sialoprotein, bone sialoprotein II)
109070	3383	hCG28476.2	ICAM1	intercellular adhesion molecule 1 (CD54), human rhinovirus receptor
155212	3384	hCG41817.4	ICAM2	intercellular adhesion molecule 2
131931	3385	hCG2033729	ICAM3	intercellular adhesion molecule 3
158761	3386	hCG28480.3	ICAM4	intercellular adhesion molecule 4, Landsteiner-Wiener blood group
116818	7087	hCG28481.3	ICAM5	intercellular adhesion molecule 5, telencephalin
202509	3484	hCG2003734	IGFBP1	insulin-like growth factor binding protein 1
161608	3485	hCG16383.3	IGFBP2	insulin-like growth factor binding protein 2, 36kDa
104923	3486	hCG1735376.2	IGFBP3	insulin-like growth factor binding protein 3
207755	3487	hCG1643839.3	IGFBP4	insulin-like growth factor binding protein 4
170211	3488	hCG16384.2	IGFBP5	insulin-like growth factor binding protein 5
150353	3489	hCG43768.2	IGFBP6	insulin-like growth factor binding protein 6
113811	3495	hCG2038940|hCG2	IGHD	immunoglobulin heavy constant delta
123277	3495	hCG2038940	IGHD	immunoglobulin heavy constant delta
134477	3495	hCG2029986.1	IGHD	immunoglobulin heavy constant delta
184949	3495	hCG2029986.1	IGHD	immunoglobulin heavy constant delta
116610	3500	hCG1773300.3	IGHG1	immunoglobulin heavy constant gamma 1 (G1m marker)
147857	3500	hCG1812897.2	IGHG1	immunoglobulin heavy constant gamma 1 (G1m marker)
191229	3500	hCG2038926	IGHG1	immunoglobulin heavy constant gamma 1 (G1m marker)
121996	3502|3500|3507|3	hCG2029987.1|hCC	IGHG3|IGHG1|IGH	immunoglobulin heavy constant gamma 3 (G3m marker)|immunoglobulin heavy constant gamma 1 (G1m marker)|immunoglobulin heavy constant mu|immunoglobulin heavy constant gamma 2 (G2m marker)
123516	3507	hCG2042717	IGHM	immunoglobulin heavy constant mu
143582	3507	hCG1773549.4	IGHM	immunoglobulin heavy constant mu
165161	3507	hCG1686394.2	IGHM	immunoglobulin heavy constant mu
178394	3507	hCG2038942	IGHM	immunoglobulin heavy constant mu
179702	3507	hCG1793614.3	IGHM	immunoglobulin heavy constant mu
214404	388077	hCG1728627.1	IGHV1OR15-1	immunoglobulin heavy variable 1/OR15-1
188579	28303|390531	hCG2038937|hCG2	IGHV3OR16-13|VSI	immunoglobulin heavy variable 3/OR16-13|V-set and immunoglobulin domain containing 7
199327	28378	hCG1773558.2	IGHV7-81	immunoglobulin heavy variable 7-81
112729	3514|28299	hCG1980528.1	IGKC|IGKV1-5	immunoglobulin kappa constant|immunoglobulin kappa variable 1-5
181039	28831	hCG2029211.2	IGLJ3	immunoglobulin lambda joining 3
172692	28831|28793|3537	hCG2040026.1	IGLJ3|IGLV3-25|IGI	immunoglobulin lambda joining 3|immunoglobulin lambda variable 3-25|immunoglobulin lambda constant 1 (Mcg marker)|immunoglobulin lambda constant 2 (Kern-Oz- marker)|immunoglobulin lambda locus
141999	3543	hCG40362.3	IGLL1	immunoglobulin lambda-like polypeptide 1
171778	3543	hCG40362.3	IGLL1	immunoglobulin lambda-like polypeptide 1
172554	28815|28786|3537	hCG2040018.1	IGLV2-14|IGLV4-3|	immunoglobulin lambda variable 2-14|immunoglobulin lambda variable 4-3|immunoglobulin lambda constant 1 (Mcg marker)|immunoglobulin lambda constant 2 (Kern-Oz- marker)
125743	28797|28831	hCG1782424.3	IGLV3-19|IGLJ3	immunoglobulin lambda variable 3-19|immunoglobulin lambda joining 3
108442	28793	hCG1782425.3	IGLV3-25	immunoglobulin lambda variable 3-25
183393	285313	hCG20916.3	IGSF10	immunoglobulin superfamily, member 10
164847	152404	hCG22570.5	IGSF11	immunoglobulin superfamily, member 11
169981	57549	hCG39736.4	IGSF9	immunoglobulin superfamily, member 9

DOI: 10.3324/haematol.2010.026740

105772	3594	hCG36879.4	IL12RB1	interleukin 12 receptor, beta 1
226063	3594	hCG36879.4	IL12RB1	interleukin 12 receptor, beta 1
160329	3611	hCG24084.3	ILK	integrin-linked kinase
194575	3617	hCG32995.2	IMPG1	interphotoreceptor matrix proteoglycan 1
154353	50939	hCG39282.4	IMPG2	interphotoreceptor matrix proteoglycan 2
146438	10207	hCG1811269.2	INADL	InaD-like (Drosophila)
116215	8515	hCG37373.3	ITGA10	integrin, alpha 10
200889	22801	hCG23809.3	ITGA11	integrin, alpha 11
223442	3673	hCG40683.3	ITGA2	integrin, alpha 2 (CD49B, alpha 2 subunit of VLA-2 receptor)
204518	3674	hCG1818596.1	ITGA2B	integrin, alpha 2b (platelet glycoprotein IIb of IIb/IIIa complex, antigen CD41B)
119181	3675	hCG27414.3	ITGA3	integrin, alpha 3 (antigen CD49C, alpha 3 subunit of VLA-3 receptor)
139326	3676	hCG1811925.1	ITGA4	integrin, alpha 4 (antigen CD49D, alpha 4 subunit of VLA-4 receptor)
145228	3678	hCG21939.2	ITGA5	integrin, alpha 5 (fibronectin receptor, alpha polypeptide)
132194	3655	hCG19171.3	ITGA6	integrin, alpha 6
185859	3679	hCG20745.2	ITGA7	integrin, alpha 7
195887	8516	hCG22614.2	ITGA8	integrin, alpha 8
157432	3680	hCG17143.3	ITGA9	integrin, alpha 9
177113	3681	hCG168149.2	ITGAD	integrin, alpha D
208380	3681	hCG168149.2	ITGAD	integrin, alpha D
137521	3682	hCG33203.3	ITGAE	integrin, alpha E (antigen CD103, human mucosal lymphocyte antigen 1; alpha polypeptide)
150031	3683	hCG18670.3	ITGAL	integrin, alpha L (antigen CD11A (p180), lymphocyte function-associated antigen 1; alpha polypeptide)
148765	3684	hCG1998613	ITGAM	integrin, alpha M (complement component receptor 3, alpha; also known as CD11b (p170), macrophage antigen alpha polypeptide)
177019	3684	null	ITGAM	integrin, alpha M (complement component receptor 3, alpha; also known as CD11b (p170), macrophage antigen alpha polypeptide)
183759	3684	hCG1998613	ITGAM	integrin, alpha M (complement component receptor 3, alpha; also known as CD11b (p170), macrophage antigen alpha polypeptide)
192502	3684	hCG1998613	ITGAM	integrin, alpha M (complement component receptor 3, alpha; also known as CD11b (p170), macrophage antigen alpha polypeptide)
117958	3685	hCG21243.2	ITGAV	integrin, alpha V (vitronectin receptor, alpha polypeptide, antigen CD51)
193647	3687	hCG1789754.2	ITGAX	integrin, alpha X (antigen CD11C (p150), alpha polypeptide)
197265	3687	null	ITGAX	integrin, alpha X (antigen CD11C (p150), alpha polypeptide)
230552	3687	null	ITGAX	integrin, alpha X (antigen CD11C (p150), alpha polypeptide)
187625	3688	hCG2001034|hCG2	ITGB1	integrin, beta 1 (fibronectin receptor, beta polypeptide, antigen CD29 includes MDF2, MSK12)
191262	3688	hCG2017385	ITGB1	integrin, beta 1 (fibronectin receptor, beta polypeptide, antigen CD29 includes MDF2, MSK12)
193585	3689	hCG401305.4	ITGB2	integrin, beta 2 (antigen CD18 (p95), lymphocyte function-associated antigen 1; macrophage antigen 1 (mac-1) beta subunit)
192782	3690	hCG27604.2	ITGB3	integrin, beta 3 (platelet glycoprotein IIIa, antigen CD61)
200414	3693	hCG17803.3	ITGB5	integrin, beta 5
100436	3694	hCG40675.2	ITGB6	integrin, beta 6
166101	3695	hCG43756.2	ITGB7	integrin, beta 7
202580	3696	hCG37311.3	ITGB8	integrin, beta 8
141969	58494	hCG401152.3	JAM2	junctional adhesion molecule 2
100510	83700	hCG37606.3	JAM3	junctional adhesion molecule 3

DOI: 10.3324/haematol.2010.026740

121647	3728	hCG1771506.1	JUP	junction plakoglobin
147107	11081	hCG22819.2	KERA	keratocan
208473	23249	hCG17390.2	KIAA0960	null
107771	80731	hCG1812660.1	KIAA1679	null
113837	3805	null	KIR2DL4	killer cell immunoglobulin-like receptor, two domains, long cytoplasmic tail, 4
202768	3805	hCG2039724.1	KIR2DL4	killer cell immunoglobulin-like receptor, two domains, long cytoplasmic tail, 4
				killer cell immunoglobulin-like receptor, two domains, long cytoplasmic tail, 5A|killer cell immunoglobulin-like receptor, two domains, long cytoplasmic tail, 2|killer cell immunoglobulin-like receptor, two domains, long cytoplasmic tail, 5B
109451	57292|3803|55312	hCG2036712	KIR2DL5A|KIR2DL2	
111378	3811	hCG2039725.1	KIR3DL1	killer cell immunoglobulin-like receptor, three domains, long cytoplasmic tail, 1
138026	3811	hCG2039725.1	KIR3DL1	killer cell immunoglobulin-like receptor, three domains, long cytoplasmic tail, 1
195291	3811	null	KIR3DL1	killer cell immunoglobulin-like receptor, three domains, long cytoplasmic tail, 1
223977	115653	hCG1732232.2	KIR3DL3	killer cell immunoglobulin-like receptor, three domains, long cytoplasmic tail, 3
142892	55243	hCG39953.3	KIRREL	kin of IRRE like (Drosophila)
161081	84063	hCG23603.2	KIRREL2	kin of IRRE like 2 (Drosophila)
168224	84623	hCG2032836.1	KIRREL3	kin of IRRE like 3 (Drosophila)
109549	4254	hCG26603.2	KITLG	KIT ligand
185131	3821	hCG95764.3	KLRC1	killer cell lectin-like receptor subfamily C, member 1
109992	3822	null	KLRC2	killer cell lectin-like receptor subfamily C, member 2
129345	3823	null	KLRC3	killer cell lectin-like receptor subfamily C, member 3
188783	8302	hCG2009644	KLRC4	killer cell lectin-like receptor subfamily C, member 4
213055	8302|22914	hCG2009644	KLRC4|KLRK1	killer cell lectin-like receptor subfamily C, member 4|killer cell lectin-like receptor subfamily K, member 1
204942	3824	hCG37262.3	KLRD1	killer cell lectin-like receptor subfamily D, member 1
167353	3897	hCG39212.2	L1CAM	L1 cell adhesion molecule
120574	3903	hCG2009346.1	LAIR1	leukocyte-associated Ig-like receptor 1
173782	3903	hCG2009346.1	LAIR1	leukocyte-associated Ig-like receptor 1
203708	3904	hCG1732218.2	LAIR2	leukocyte-associated Ig-like receptor 2
105409	284217	hCG1781103.3	LAMA1	laminin, alpha 1
173221	284217	null	LAMA1	laminin, alpha 1
149994	3908	hCG21784.2	LAMA2	laminin, alpha 2 (merosin, congenital muscular dystrophy)
131641	3909	hCG1811249.2	LAMA3	laminin, alpha 3
101059	3910	hCG32955.4	LAMA4	laminin, alpha 4
201249	3911	hCG41774.3	LAMA5	laminin, alpha 5
117740	3912	hCG17112.2	LAMB1	laminin, beta 1
176679	3913	hCG96721.3	LAMB2	laminin, beta 2 (laminin S)
176623	3914	hCG21281.3	LAMB3	laminin, beta 3
124914	22798	hCG1811708.1	LAMB4	laminin, beta 4
180055	3915	hCG40729.2	LAMC1	laminin, gamma 1 (formerly LAMB2)
201627	3918	hCG40730.3	LAMC2	laminin, gamma 2
111334	10319	hCG30194.3	LAMC3	laminin, gamma 3
197253	64175	hCG23171.2	LEPRE1	leucine proline-enriched proteoglycan (leprecan) 1
121792	55214	hCG1811845.1	LEPREL1	leprecan-like 1
134755	55214	hCG1811845.1	LEPREL1	leprecan-like 1
170997	10536	hCG2039832	LEPREL2	leprecan-like 2

DOI: 10.3324/haematol.2010.026740

151835		3956	hCG41838.4	LGALS1	lectin, galactoside-binding, soluble, 1 (galectin 1)
134359		85329	hCG21321.4	LGALS12	lectin, galactoside-binding, soluble, 12 (galectin 12)
164746		29124	hCG43351.3	LGALS13	lectin, galactoside-binding, soluble, 13 (galectin 13)
205962		56891	hCG1645558.3	LGALS14	lectin, galactoside-binding, soluble, 14
112586		3957	hCG41839.3	LGALS2	lectin, galactoside-binding, soluble, 2 (galectin 2)
179836	3958|81625		hCG22119.3	LGALS3|GALIG	lectin, galactoside-binding, soluble, 3 (galectin 3)
185853		3959	hCG1776358.1	LGALS3BP	lectin, galactoside-binding, soluble, 3 binding protein
207509		3960	hCG20525.3	LGALS4	lectin, galactoside-binding, soluble, 4 (galectin 4)
130092		3963	hCG1776519.3|hC(	LGALS7	lectin, galactoside-binding, soluble, 7 (galectin 7)
151391		3964	hCG23447.4	LGALS8	lectin, galactoside-binding, soluble, 8 (galectin 8)
159046		3965	null	LGALS9	lectin, galactoside-binding, soluble, 9 (galectin 9)
195916		11027	hCG19661.4	LILRA2	leukocyte immunoglobulin-like receptor, subfamily A (with TM domain), member 2
102060		11026	hCG2043692	LILRA3	leukocyte immunoglobulin-like receptor, subfamily A (without TM domain), member 3
156072		23547	null	LILRA4	leukocyte immunoglobulin-like receptor, subfamily A (with TM domain), member 4
176231		353514	hCG2009348.1	LILRA5	leukocyte immunoglobulin-like receptor, subfamily A (with TM domain), member 5
183963		10859	hCG20655.3	LILRB1	leukocyte immunoglobulin-like receptor, subfamily B (with TM and ITIM domains), member 1
212855	10859|11024		null	LILRB1|LILRA1	leukocyte immunoglobulin-like receptor, subfamily B (with TM and ITIM domains), member 1|leukocyte immunoglobulin-like receptor, subfamily A (with TM domain), member 1
150853		10288	hCG2041477.1	LILRB2	leukocyte immunoglobulin-like receptor, subfamily B (with TM and ITIM domains), member 2
113190	10288|11025		hCG2043691	LILRB2|LILRB3	leukocyte immunoglobulin-
183799		10990	hCG2039978.1	LILRB5	leukocyte immunoglobulin-like receptor, subfamily B (with TM and ITIM domains), member 5
126995		3982	hCG91964.3	LIM2	lens intrinsic membrane protein 2, 19kDa
183828		8825	hCG1774002.2	LIN7A	lin-7 homolog A (C. elegans)
102972		64130	hCG16223.4	LIN7B	lin-7 homolog B (C. elegans)
217099		55327	hCG27394.3	LIN7C	lin-7 homolog C (C. elegans)
137750		84708	hCG21520.3	LNX1	ligand of numb-protein X 1
189271		84708	hCG21520.3	LNX1	ligand of numb-protein X 1
146114		222484	hCG30819.3	LNX2	ligand of numb-protein X 2
105532		126987	hCG2040319	LOC126987	null
225218		131149	hCG2036643	LOC131149	null
166736		148003	hCG1776529.2	LOC148003	null
188269		253012	null	LOC253012	null
228470		253012	hCG2023308	LOC253012	null
191927		283804	null	LOC283804	null
183890		284623	hCG1645093.3	LOC284623	null
208099		389174	hCG1786642.1	LOC389174	null
106052		390299	hCG38093.3	LOC390299	null
235383		390712	hCG1793095.2	LOC390712	null
107637	401393|402571		hCG1770601.2	LOC401393|LOC40	null
189914		401845	hCG1742309.1	LOC401845	null
235488	401847|339221		hCG2036665|hCG1	LOC401847|ENPP7	ectonucleotide pyrophosphatase/phosphodiesterase 7
175634	439957|389953		hCG1742442.1	LOC439957|LOC38	null
125922		440508	hCG2038374.1|hC(	LOC440508	null

DOI: 10.3324/haematol.2010.026740

136617		440508	hCG2038374.1|hC	LOC440508	null
235409	440557|1953		hCG2005209	LOC440557|EGFL3	EGF-like-domain, multiple 3
179815	440607|2209		null	LOC440607|FCGR1	Fc fragment of IgG, high affinity Ia, receptor (CD64)
146353		440786	hCG1997566	LOC440786	null
183428		440786	hCG1642538.2	LOC440786	null
147635		441789	hCG1639960.4	LOC441789	null
170396		442654	hCG18434.3	LOC442654	null
185313	594834|143162|59		hCG1725443.3	LOC594834|FRMPI	FERM and PDZ domain containing 2
203565		91316	hCG1812916.2	LOC91316	null
123366		96610	hCG91933.4	LOC96610	null
195189		96610	hCG91933.4	LOC96610	null
154117		131578	hCG2043616	LRRC15	leucine rich repeat containing 15
231921		131578	hCG2043616	LRRC15	leucine rich repeat containing 15
128091		4045	hCG2022843.1	LSAMP	limbic system-associated membrane protein
119769		4052	hCG1988218.1	LTBP1	latent transforming growth factor beta binding protein 1
116441		4053	hCG1811460.1	LTBP2	latent transforming growth factor beta binding protein 2
188681		4053	hCG1811460.1	LTBP2	latent transforming growth factor beta binding protein 2
129768		4054	hCG1812642.1	LTBP3	latent transforming growth factor beta binding protein 3
162965		8425	hCG20254.3	LTBP4	latent transforming growth factor beta binding protein 4
178828		4059	hCG22133.3	LU	Lutheran blood group (Auberger b antigen included)
196622		4060	hCG24108.2	LUM	lumican
170428		4063	hCG27852.3	LY9	lymphocyte antigen 9
117425	4069|10859		hCG24462.3	LYZ|LILRB1	lysozyme (renal amyloidosis)|leukocyte immunoglobulin-like receptor, subfamily B (with TM and ITIM domains), member 1
109132		4099	hCG23606.3	MAG	myelin associated glycoprotein
151953		4099	hCG23606.3	MAG	myelin associated glycoprotein
132878	4099|933		hCG23580.2	MAG|CD22	myelin associated glycoprotein|CD22 antigen
110909		9223	hCG1777570.2	MAGI1	membrane associated guanylate kinase, WW and PDZ domain containing 1
105744		9863	hCG1643736.3	MAGI2	membrane associated guanylate kinase, WW and PDZ domain containing 2
208911		9863	hCG2023734	MAGI2	membrane associated guanylate kinase, WW and PDZ domain containing 2
210254		9863	hCG40263.3	MAGI2	membrane associated guanylate kinase, WW and PDZ domain containing 2
109989		260425	hCG2043269	MAGI3	membrane associated guanylate kinase, WW and PDZ domain containing 3
224893		260425	hCG2043269	MAGI3	membrane associated guanylate kinase, WW and PDZ domain containing 3
162270		4146	hCG15912.4	MATN1	matrilin 1, cartilage matrix protein
232416		4146	hCG2033299	MATN1	matrilin 1, cartilage matrix protein
167316		4147	hCG17257.3	MATN2	matrilin 2
116706		4148	hCG32088.2	MATN3	matrilin 3
172051		8785	hCG38364.4	MATN4	matrilin 4
165409		4162	hCG15250.2	MCAM	melanoma cell adhesion molecule
125929		84466	hCG1812094.1	MEGF10	null
135724		84465	hCG1811977.2	MEGF11	null
162212		4237	hCG25122.2	MFAP2	microfibrillar-associated protein 2
132629		4238	hCG1820732.1	MFAP3	microfibrillar-associated protein 3
218511		9848	hCG17310.3	MFAP3L	microfibrillar-associated protein 3-like
151056		4239	hCG30687.3	MFAP4	microfibrillar-associated protein 4
112547		8076	hCG25217.3	MFAP5	microfibrillar associated protein 5

DOI: 10.3324/haematol.2010.026740

144588	4240	hCG26628.2	MFGE8	milk fat globule-EGF factor 8 protein
218598	112812	hCG2033729	MGC19604	null
118811	283650	hCG2029251.1	MGC27165	null
220939	283650|3493|3494	hCG1988537.1	MGC27165|IGHA1	immunoglobulin heavy constant alpha 1|immunoglobulin heavy constant alpha 2 (A2m marker)
232718	338872	hCG2033348.1	MGC48915	null
121617	4256	hCG24416.2	MGP	matrix Gla protein
190435	4256	hCG24416.2	MGP	matrix Gla protein
102347	117153	hCG1785689.1	MIA2	melanoma inhibitory activity 2
224708	117153	hCG1785689.1	MIA2	melanoma inhibitory activity 2
128509	22915	hCG38707.3	MMRN1	multimerin 1
155462	79812	hCG23267.4	MMRN2	multimerin 2
161318	8777	hCG27257.3	MPDZ	multiple PDZ domain protein
184780	401827	hCG1644790.2	MPFL	null
139073	4359	hCG37881.3	MPZ	myelin protein zero (Charcot-Marie-Tooth neuropathy 1B)
206371	9019	hCG42390.4	MPZL1	myelin protein zero-like 1
208490	9019	hCG42390.4	MPZL1	myelin protein zero-like 1
182643	2206	hCG40395.2	MS4A2	membrane-spanning 4-domains, subfamily A, member 2 (Fc fragment of IgE, high affinity I, receptor for; beta polypeptide)
147075	10232	hCG22420.3	MSLN	mesothelin
110673	283463	hCG1806044.2	MUC19	mucin 19
115305	283463	hCG1818434.2	MUC19	mucin 19
189742	283463	hCG2036593	MUC19	mucin 19
198392	4583	hCG1778312.2	MUC2	mucin 2, intestinal/tracheal
101157	4585	hCG1994601	MUC4	mucin 4, tracheobronchial
145989	4585	null	MUC4	mucin 4, tracheobronchial
235587	4585	hCG1994601	MUC4	mucin 4, tracheobronchial
112894	4586	hCG1778310.1	MUC5AC	mucin 5, subtypes A and C, tracheobronchial/gastric
136305	4586	null	MUC5AC	mucin 5, subtypes A and C, tracheobronchial/gastric
173699	4587	hCG1993440	MUC5B	mucin 5, subtype B, tracheobronchial
113554	4588	null	MUC6	mucin 6, gastric
182122	4588	hCG1778326.1	MUC6	mucin 6, gastric
179125	53841	hCG1778294.1	MUCDHL	mucin and cadherin-like
139495	25878	hCG1981880	MXRA5	matrix-remodelling associated 5
101574	4638	hCG2022707	MYLK	myosin, light polypeptide kinase
130884	4684	hCG2032571.1	NCAM1	neural cell adhesion molecule 1
172702	4685	hCG2007901.1	NCAM2	neural cell adhesion molecule 2
199050	4685	hCG2007901.1	NCAM2	neural cell adhesion molecule 2
142840	23154	hCG38291.3	NCDN	neurochondrin
164589	9437	hCG19670.3	NCR1	natural cytotoxicity triggering receptor 1
111793	257194	hCG1640013.4	NEGR1	neuronal growth regulator 1
211059	257194	hCG1640013.4	NEGR1	neuronal growth regulator 1
186099	4756	hCG2003750	NEO1	neogenin homolog 1 (chicken)
193005	23114	hCG16415.3	NFASC	neurofascin homolog (chicken)
233377	23114	hCG2025385	NFASC	neurofascin homolog (chicken)
200980	4811	hCG25457.3	NID1	nidogen 1
108491	22795	hCG20960.2	NID2	nidogen 2 (osteonidogen)

DOI: 10.3324/haematol.2010.026740

181718		4814	hCG18015.3	NINJ1	ninjurin 1
184147		4815	hCG25274.2	NINJ2	ninjurin 2
110809		22871	hCG2021529.1	NLGN1	neuroligin 1
180149		57555	hCG42031.5	NLGN2	neuroligin 2
179213		54413	hCG1724001.2	NLGN3	neuroligin 3
146373		57502	hCG1982900.2	NLGN4X	neuroligin 4, X-linked
215545		22829	hCG1988457.1	NLGN4Y	neuroligin 4, Y-linked
203782		57722	hCG23665.2	NOPE	null
126517		4851	hCG1818285.2	NOTCH1	Notch homolog 1, translocation-associated (Drosophila)
142906		4853	hCG37617.3	NOTCH2	Notch homolog 2 (Drosophila)
128130	4853|388677		null	NOTCH2|NOTCH2N	Notch homolog 2 (Drosophila)|Notch homolog 2 (Drosophila) N-terminal like
130268	4853|388677		null	NOTCH2|NOTCH2N	Notch homolog 2 (Drosophila)|Notch homolog 2 (Drosophila) N-terminal like
149230		4854	hCG38585.3	NOTCH3	Notch homolog 3 (Drosophila)
104948		4868	hCG2042774	NPHS1	nephrosis 1, congenital, Finnish type (nephrin)
179656		255743	hCG2030518.1	NPNT	nephronectin
219954		255743	hCG2030518.1	NPNT	nephronectin
106462		4897	hCG17111.4	NRCAM	neuronal cell adhesion molecule
204811		9378	hCG1817742.1	NRXN1	neurexin 1
208420		9379	hCG1810991.1	NRXN2	neurexin 2
139725		9369	hCG1811459.2	NRXN3	neurexin 3
156427		9369	hCG1811459.2	NRXN3	neurexin 3
135850		9423	hCG1811055.1	NTN1	netrin 1
211806		4917	hCG32964.2	NTN2L	netrin 2-like (chicken)
185137		59277	hCG33113.3	NTN4	netrin 4
200177		22854	hCG1811122.1	NTNG1	netrin G1
147584		84628	hCG31462.3	NTNG2	netrin G2
102071	null		hCG2039487	null	null
102086	null		hCG1737355.4	null	null
102721	null		hCG1793614.3	null	null
102778	null		hCG1793766.2	null	null
105086	null		hCG2041342	null	null
107477	null		hCG2001494.2	null	null
107676	null		hCG1686410.4	null	null
107967	null		hCG1685759.3	null	null
108493	null		hCG2029236.1	null	null
108546	null		hCG1737376.3	null	null
108776	null		hCG2038931.1	null	null
109112	null		hCG2041607.1	null	null
109596	null		hCG1812158.2	null	null
111534	null		hCG1794504.3	null	null
112906	null		hCG2039499	null	null
112952	null		hCG1737360.3	null	null
113298	null		hCG19987.4	null	null
113639	null		hCG2041413	null	null
114396	null		hCG1723911.2	null	null

DOI: 10.3324/haematol.2010.026740

114413	null	hCG1650725.3	null	null
115430	null	hCG1812151.2	null	null
117977	null	hCG1812137.2	null	null
118448	null	hCG2040022.1	null	null
120363	null	hCG1741832.4	null	null
121378	null	hCG1737378.3	null	null
123649	null	hCG1812116.2	null	null
125786	null	hCG1652195.2	null	null
125874	null	hCG1642807.3	null	null
126154	null	hCG2040640.1	null	null
126586	null	hCG2038930	null	null
126783	null	hCG1812141.2	null	null
126918	null	hCG37525.2	null	null
128872	null	hCG1737367.3	null	null
129252	null	hCG2039476|hCG2	null	null
130687	null	hCG2003544	null	null
132779	null	hCG2039494.1|hC(	null	null
132946	null	hCG1723904.3	null	null
133305	null	hCG1732230.3	null	null
133318	null	hCG1773460.3	null	null
134361	null	hCG2039505	null	null
134541	null	hCG1791795.2	null	null
134542	null	hCG1746482.2	null	null
135354	null	hCG1749806.2	null	null
135488	null	hCG1778883.4	null	null
135954	null	hCG1685755.3	null	null
136455	null	hCG2014363.1	null	null
136785	null	hCG2042707	null	null
136826	null	hCG2039486	null	null
138080	null	hCG2038932	null	null
139777	null	hCG1737379.3	null	null
141031	null	hCG2014363.1	null	null
141132	null	hCG1812069.2	null	null
142163	null	hCG1812140.2	null	null
143028	null	hCG2039526	null	null
143812	null	hCG2043237	null	null
143822	null	hCG1686194.2	null	null
143962	null	hCG1745487.2	null	null
145456	null	hCG2038918	null	null
146688	null	hCG1812142.2	null	null
149336	null	hCG1737365.3	null	null
151826	null	hCG1812939.2	null	null
152208	null	hCG1812772.3	null	null
152990	null	hCG2043208	null	null
153177	null	hCG2040257	null	null

DOI: 10.3324/haematol.2010.026740

154783	null	hCG2038943	null	null
155187	null	hCG2040019.1	null	null
156048	null	hCG1782423.3	null	null
158059	null	hCG2001501.1	null	null
159221	null	hCG1746206.2	null	null
160175	null	hCG1812125.2	null	null
161179	null	hCG2039475	null	null
161488	null	hCG2042722	null	null
162365	null	hCG2042833	null	null
163325	null	hCG2039497	null	null
163856	null	hCG1812133.2	null	null
164834	null	hCG2039504	null	null
165263	null	hCG2039696	null	null
165736	null	hCG1980528.1	null	null
166879	null	hCG1788965.4	null	null
168085	null	hCG2001460.1	null	null
168964	null	hCG1812916.2	null	null
169042	null	hCG2040636	null	null
169595	null	hCG2001464.2|hC(	null	null
171078	null	hCG1737367.3|hC(	null	null
171156	null	hCG2043242|hCG1	null	null
171594	null	hCG2002964.1	null	null
172955	null	hCG1789507.3	null	null
173905	null	hCG1812939.2|hC(	null	null
175627	null	hCG2039482|hCG2	null	null
176977	null	hCG1686079.4	null	null
177583	null	hCG1980528.1	null	null
178480	null	hCG2041292.1	null	null
179234	null	hCG91935.4	null	null
180081	null	hCG2033673.1	null	null
180452	null	hCG2014363.1	null	null
180759	null	hCG1821225.2	null	null
180795	null	hCG2039492	null	null
181278	null	hCG1749806.2	null	null
181496	null	hCG2039490.1	null	null
181654	null	hCG2041210.1	null	null
181990	null	hCG2038939	null	null
182044	null	hCG2014128.1	null	null
182098	null	hCG1641609.2	null	null
184105	null	hCG2041221.1	null	null
185597	null	hCG1792523.3	null	null
187056	null	hCG2039496	null	null
187428	null	hCG1646346.4	null	null
187836	null	hCG2002981.1	null	null
188651	null	hCG1773456.3	null	null

DOI: 10.3324/haematol.2010.026740

189056	null	hCG1737371.3	null	null
189409	null	hCG1794860.3	null	null
189504	null	hCG1773460.3	null	null
190259	null	hCG1642698.4	null	null
190632	null	hCG1685763.3	null	null
192250	null	hCG2002980.1	null	null
192742	null	hCG2038941	null	null
192909	null	hCG2033675.1	null	null
192959	null	hCG2002958.1	null	null
193687	null	hCG2038923	null	null
194317	null	hCG1729900.1	null	null
194908	null	hCG2033671.1	null	null
198315	null	hCG2029256.2	null	null
198444	null	hCG1773462.4	null	null
198839	null	hCG2033671.1|hC(	null	null
198859	null	hCG2039500	null	null
199303	null	hCG41214.4	null	null
201095	null	hCG1731877.3	null	null
202646	null	hCG1773456.3	null	null
204418	null	hCG1724275.3	null	null
204595	null	hCG1646420.1	null	null
205609	null	hCG2002986.2	null	null
205682	null	hCG1769458.2	null	null
206632	null	hCG2038924	null	null
206761	null	hCG2043257	null	null
208397	null	hCG1737363.3	null	null
209971	null	hCG2039509	null	null
212308	null	hCG2043266	null	null
212405	null	hCG2010499.1	null	null
213498	null	hCG1644548.4	null	null
218655	null	hCG2036731	null	null
219410	null	hCG2036696.1	null	null
222973	null	hCG2042405	null	null
223669	null	hCG2038939	null	null
229345	null	hCG1686409.3	null	null
229600	null	hCG1644325.2	null	null
230639	null	hCG2006266	null	null
230795	null	hCG1812150.2	null	null
231767	null	hCG1812130.1	null	null
231829	null	hCG2010526.1	null	null
233204	null	hCG1640134.3	null	null
233230	null	hCG21885.2	null	null
233771	null	hCG2043432	null	null
234484	null	hCG2014449.1	null	null
234910	null	hCG2043197	null	null

DOI: 10.3324/haematol.2010.026740

235353	null	hCG2010697.1	null	null
236107	null	hCG1794122.3	null	null
236534	null	hCG19326.2	null	null
236974	null	hCG1991431.1|hC(	null	null
237069	null	hCG1737330.1	null	null
108955	4950	hCG37070.2	OCLN	occludin
197167	10178	hCG2039411.1	ODZ1	odz, odd Oz/ten-m homolog 1(Drosophila)
232770	57451	hCG38403.3	ODZ2	odz, odd Oz/ten-m homolog 2 (Drosophila)
178643	55714	hCG2025760	ODZ3	odz, odd Oz/ten-m homolog 3 (Drosophila)
119908	26011	hCG2016781	ODZ4	odz, odd Oz/ten-m homolog 4 (Drosophila)
199889	26011	hCG2016781	ODZ4	odz, odd Oz/ten-m homolog 4 (Drosophila)
124380	4958	hCG28128.2	OMD	osteomodulin
108259	4978	hCG1811667.1	OPCML	opioid binding protein/cell adhesion molecule-like
169776	4983	hCG14944.2	OPHN1	oligophrenin 1
136287	126014	hCG20955.3	OSCAR	null
174318	126014	hCG20955.3	OSCAR	null
159546	146183	hCG2043047	OTOA	otoancorin
235100	146183	hCG2043047	OTOA	otoancorin
138764	89932	hCG21526.3	PAPLN	papilin, proteoglycan-like sulfated glycoprotein
116049	56288	hCG21413.3	PARD3	par-3 partitioning defective 3 homolog (C. elegans)
194369	50855	hCG2025821	PARD6A	par-6 partitioning defective 6 homolog alpha (C.elegans)
113036	84612	hCG37110.3	PARD6B	par-6 partitioning defective 6 homolog beta (C. elegans)
137704	84552	hCG1643224.2	PARD6G	par-6 partitioning defective 6 homolog gamma (C. elegans)
122520	5097	hCG1641133.3	PCDH1	protocadherin 1 (cadherin-like 1)
164845	5097	hCG1641133.3	PCDH1	protocadherin 1 (cadherin-like 1)
116092	57575	hCG2026367	PCDH10	protocadherin 10
226808	57575	hCG2026367	PCDH10	protocadherin 10
183881	27328	hCG1797565.2	PCDH11X	protocadherin 11 X-linked
168835	27328|83259	hCG1797565.2	PCDH11X|PCDH11\	protocadherin 11 X-linked|protocadherin 11 Y-linked
209765	27328|83259	hCG1797565.2	PCDH11X|PCDH11\	protocadherin 11 X-linked|protocadherin 11 Y-linked
221347	27328|83259	hCG1797565.2	PCDH11X|PCDH11\	protocadherin 11 X-linked|protocadherin 11 Y-linked
101331	51294	hCG36994.2	PCDH12	protocadherin 12
200947	65217	hCG1651788.3	PCDH15	protocadherin 15
134951	27253	hCG27727.2	PCDH17	protocadherin 17
199474	54510	hCG16335.3	PCDH18	protocadherin 18
105655	57526	hCG20190.2	PCDH19	protocadherin 19
100781	64881	hCG1643344.2	PCDH20	protocadherin 20
203213	92211	hCG1811065.1	PCDH21	protocadherin 21
108465	5099	hCG2026913	PCDH7	BH-protocadherin (brain-heart)
213562	5100	hCG27503.4	PCDH8	protocadherin 8
130673	5101	hCG1646493.3	PCDH9	protocadherin 9
170220	56147	null	PCDHA1	protocadherin alpha 1
194638	56147	hCG1982192	PCDHA1	protocadherin alpha 1
211513	56139	hCG1982192	PCDHA10	protocadherin alpha 10
136297	56138	hCG1982192	PCDHA11	protocadherin alpha 11

DOI: 10.3324/haematol.2010.026740

105415	56137	hCG1982192	PCDHA12	protocadherin alpha 12
222543	56136	hCG1982192	PCDHA13	protocadherin alpha 13
222659	56146	hCG1982192	PCDHA2	protocadherin alpha 2
187975	56145	hCG1982192	PCDHA3	protocadherin alpha 3
151475	56144	hCG1982192	PCDHA4	protocadherin alpha 4
168081	56144	hCG1982192	PCDHA4	protocadherin alpha 4
123496	56144|56134|5614	hCG1982192	PCDHA4|PCDHAC2	protocadherin alpha 4|protocadherin alpha subfamily C, 2|protocadherin alpha 7|protocadherin alpha 9|protocadherin alpha 5|protocadherin alpha 10|protocadherin alpha 3|protocadherin alpha 2|protocadherin alpha 1|protocadherin alpha 8|protocadherin alpha 6|protocadherin alpha subfamily C, 1|protocadherin alpha 13|protocadherin alpha 11|protocadherin alpha 12
124958	56143	hCG1982192	PCDHA5	protocadherin alpha 5
173585	56143	null	PCDHA5	protocadherin alpha 5
210589	56142	hCG1982192	PCDHA6	protocadherin alpha 6
147844	56141	hCG1982192	PCDHA7	protocadherin alpha 7
184543	56141	hCG1982192	PCDHA7	protocadherin alpha 7
194941	56140	hCG1982192	PCDHA8	protocadherin alpha 8
218115	9752	hCG1982192	PCDHA9	protocadherin alpha 9
183700	56135	hCG1982192	PCDHAC1	protocadherin alpha subfamily C, 1
221123	56134	hCG1982192	PCDHAC2	protocadherin alpha subfamily C, 2
141421	29930	hCG42517.3	PCDHB1	protocadherin beta 1
212558	56126	hCG1982206.1	PCDHB10	protocadherin beta 10
141446	56125	hCG2039153	PCDHB11	protocadherin beta 11
114557	56124	hCG42513.2	PCDHB12	protocadherin beta 12
152367	56123	hCG1641131.3	PCDHB13	protocadherin beta 13
221361	56123	hCG1641131.3	PCDHB13	protocadherin beta 13
172671	56122	hCG2042863	PCDHB14	protocadherin beta 14
199363	56121	hCG2042865.1	PCDHB15	protocadherin beta 15
156268	57717	hCG1818480.2	PCDHB16	protocadherin beta 16
218519	57717	hCG1818480.2	PCDHB16	protocadherin beta 16
218372	54661	hCG42520.3	PCDHB17	protocadherin beta 17 pseudogene
218472	56133	hCG1818374.1	PCDHB2	protocadherin beta 2
199477	56132	hCG42518.3	PCDHB3	protocadherin beta 3
106932	56131	hCG1817972.1	PCDHB4	protocadherin beta 4
169402	26167	hCG42510.2	PCDHB5	protocadherin beta 5
138911	56130	hCG42511.3	PCDHB6	protocadherin beta 6
196274	56129	hCG1982202	PCDHB7	protocadherin beta 7
169799	56128	hCG1817973.1	PCDHB8	protocadherin beta 8
189327	56127	hCG1817969.1	PCDHB9	protocadherin beta 9
131242	56114	hCG1982215.1	PCDHGA1	protocadherin gamma subfamily A, 1
218524	56105	hCG1982215.1	PCDHGA11	protocadherin gamma subfamily A, 11
226088	26025	hCG1982215.1	PCDHGA12	protocadherin gamma subfamily A, 12
218348	56113	hCG1982215.1	PCDHGA2	protocadherin gamma subfamily A, 2
221896	56112	hCG1982215.1	PCDHGA3	protocadherin gamma subfamily A, 3
223790	56111	hCG1982215.1	PCDHGA4	protocadherin gamma subfamily A, 4

DOI: 10.3324/haematol.2010.026740

224303	56110	hCG1982215.1	PCDHGA5	protocadherin gamma subfamily A, 5
224541	56109	hCG1982215.1	PCDHGA6	protocadherin gamma subfamily A, 6
226913	56108	hCG1982215.1	PCDHGA7	protocadherin gamma subfamily A, 7
111441	9708	hCG1982215.1	PCDHGA8	protocadherin gamma subfamily A, 8
128299	9708	hCG1982215.1	PCDHGA8	protocadherin gamma subfamily A, 8
223334	56107	hCG1982215.1	PCDHGA9	protocadherin gamma subfamily A, 9
219556	56104	hCG1982215.1	PCDHGB1	protocadherin gamma subfamily B, 1
220056	56103	hCG1982215.1	PCDHGB2	protocadherin gamma subfamily B, 2
217779	56102	hCG1982215.1	PCDHGB3	protocadherin gamma subfamily B, 3
222534	8641	hCG1982215.1	PCDHGB4	protocadherin gamma subfamily B, 4
222533	56101	hCG1982215.1	PCDHGB5	protocadherin gamma subfamily B, 5
209182	56101|5098|9708	hCG1982215.1	PCDHGB5|PCDHGC	protocadherin gamma subfamily B, 5|protocadherin gamma subfamily C, 3|protocadherin gamma subfamily A, 8|protocadherin gamma subfamily C, 5|protocadherin gamma subfamily B, 3|protocadherin gamma subfamily B, 1|protocadherin gamma subfamily A, 2|protocadherin gamma subfamily A, 5|protocadherin gamma subfamily B, 6|protocadherin gamma subfamily B, 4|protocadherin gamma subfamily B, 7|protocadherin gamma subfamily A, 6|protocadherin gamma subfamily B, 2|protocadherin gamma subfamily A, 10|protocadherin gamma subfamily A, 3|protocadherin gamma subfamily A, 4|protocadherin gamma subfamily A, 11|protocadherin gamma subfamily A, 9|protocadherin gamma subfamily A, 7|protocadherin gamma subfamily C, 4|protocadherin gamma subfamily A, 12|protocadherin gamma subfamily A, 1
217907	56100	hCG1982215.1	PCDHGB6	protocadherin gamma subfamily B, 6
227600	56099	hCG1982215.1	PCDHGB7	protocadherin gamma subfamily B, 7
226138	5098	hCG1982215.1	PCDHGC3	protocadherin gamma subfamily C, 3
167693	56098	hCG1982215.1	PCDHGC4	protocadherin gamma subfamily C, 4
173538	56097	hCG1982215.1	PCDHGC5	protocadherin gamma subfamily C, 5
136478	54825	hCG1811548.2	PCLKC	null
173927	27445	hCG19253.3	PCLO	piccolo (presynaptic cytomatrix protein)
176448	27445	hCG19253.3	PCLO	piccolo (presynaptic cytomatrix protein)
136723	54760	hCG21590.3	PCSK4	proprotein convertase subtilisin/kexin type 4
122279	375033	hCG1775249.1	PEAR1	null
103150	5175	hCG2002097	PECAM1	platelet/endothelial cell adhesion molecule (CD31 antigen)
101225	53918	hCG2002731.1	PELO	pelota homolog (Drosophila)
188607	23556	hCG34285.3	PIGN	phosphatidylinositol glycan, class N
106160	5284	hCG1640654.3	PIGR	polymeric immunoglobulin receptor
100567	29992	hCG2039461	PILRA	paired immunoglobin-like type 2 receptor alpha
142909	29992	hCG2039461	PILRA	paired immunoglobin-like type 2 receptor alpha
125539	29990	hCG2024112.3	PILRB	paired immunoglobin-like type 2 receptor beta
179697	5317	hCG17681.2	PKP1	plakophilin 1 (ectodermal dysplasia/skin fragility syndrome)
200918	5318	hCG1685949.3	PKP2	plakophilin 2
174008	11187	hCG1812073.1	PKP3	plakophilin 3
129144	8502	hCG15894.3	PKP4	plakophilin 4
105793	5411	hCG21240.3	PNN	pinin, desmosome associated protein
188528	10631	hCG32814.3	POSTN	periostin, osteoblast specific factor
148513	5549	hCG24330.2	PRELP	proline/arginine-rich end leucine-rich repeat protein
204370	5553	hCG39762.3	PRG2	proteoglycan 2, bone marrow (natural killer cell activator, eosinophil granule major basic protein)

DOI: 10.3324/haematol.2010.026740

160610	10394	hCG39761.2	PRG3	proteoglycan 3
103465	283659	hCG40052.4	PRTG	protogenin homolog (Gallus gallus)
174525	283659	hCG40052.4	PRTG	protogenin homolog (Gallus gallus)
194189	283659	hCG40052.4	PRTG	protogenin homolog (Gallus gallus)
211648	5669	null	PSG1	pregnancy specific beta-1-glycoprotein 1
120399	5669|440533	hCG1996823.1|hC(	PSG1|PSG8	pregnancy specific beta-1-glycoprotein 1|pregnancy specific beta-1-glycoprotein 8
110156	5680	null	PSG11	pregnancy specific beta-1-glycoprotein 11
115454	5680	hCG1995685	PSG11	pregnancy specific beta-1-glycoprotein 11
173477	5670	hCG1995684	PSG2	pregnancy specific beta-1-glycoprotein 2
212146	5671	hCG1996826	PSG3	pregnancy specific beta-1-glycoprotein 3
110524	5672	hCG1730647.3	PSG4	pregnancy specific beta-1-glycoprotein 4
211649	5672	hCG1730647.3	PSG4	pregnancy specific beta-1-glycoprotein 4
228607	5672	hCG1995681	PSG4	pregnancy specific beta-1-glycoprotein 4
101520	5673	null	PSG5	pregnancy specific beta-1-glycoprotein 5
114219	5675	hCG1995687	PSG6	pregnancy specific beta-1-glycoprotein 6
139074	5676	hCG1995686	PSG7	pregnancy specific beta-1-glycoprotein 7
130276	5678	null	PSG9	pregnancy specific beta-1-glycoprotein 9
163073	5678	hCG1995680.1	PSG9	pregnancy specific beta-1-glycoprotein 9
148685	9051	hCG40801.3	PSTPIP1	proline-serine-threonine phosphatase interacting protein 1
141843	9050	hCG24029.3	PSTPIP2	proline-serine-threonine phosphatase interacting protein 2
120616	5754	hCG2001916.1	PTK7	PTK7 protein tyrosine kinase 7
102823	5781	hCG1782075.4	PTPN11	protein tyrosine phosphatase, non-receptor type 11 (Noonan syndrome 1)
138702	5781	hCG1782075.4	PTPN11	protein tyrosine phosphatase, non-receptor type 11 (Noonan syndrome 1)
166714	5781	hCG1782075.4|hC(	PTPN11	protein tyrosine phosphatase, non-receptor type 11 (Noonan syndrome 1)
177334	5781	hCG2012249|hCG1	PTPN11	protein tyrosine phosphatase, non-receptor type 11 (Noonan syndrome 1)
220025	5781	hCG1782075.4	PTPN11	protein tyrosine phosphatase, non-receptor type 11 (Noonan syndrome 1)
126260	5782	hCG40623.2	PTPN12	protein tyrosine phosphatase, non-receptor type 12
148473	26191	hCG38640.3	PTPN22	protein tyrosine phosphatase, non-receptor type 22 (lymphoid)
173497	26191	hCG38640.3	PTPN22	protein tyrosine phosphatase, non-receptor type 22 (lymphoid)
116804	5786	hCG2020289.1	PTPRA	protein tyrosine phosphatase, receptor type, A
162336	5789	hCG27282.2	PTPRD	protein tyrosine phosphatase, receptor type, D
221568	5791	hCG40952.4	PTPRE	protein tyrosine phosphatase, receptor type, E
200143	5792	hCG25208.2	PTPRF	protein tyrosine phosphatase, receptor type, F
187454	5796	hCG2030406	PTPRK	protein tyrosine phosphatase, receptor type, K
116034	5797	hCG38134.2	PTPRM	protein tyrosine phosphatase, receptor type, M
150889	374462	hCG1644439.3	PTPRQ	protein tyrosine phosphatase, receptor type, Q
161959	5802	hCG23499.3	PTPRS	protein tyrosine phosphatase, receptor type, S
111501	11122	hCG1812093.1	PTPRT	protein tyrosine phosphatase, receptor type, T
203973	10076	hCG1811709.1	PTPRU	protein tyrosine phosphatase, receptor type, U
170320	9543	hCG1786864.2	PUNC	putative neuronal cell adhesion molecule
149750	5817	hCG1996181.1	PVR	poliovirus receptor
197686	5818	hCG1818422.1	PVRL1	poliovirus receptor-related 1 (herpesvirus entry mediator C; nectin)
128369	5819	hCG22130.3	PVRL2	poliovirus receptor-related 2 (herpesvirus entry mediator B)
179834	25945	hCG1779876.3	PVRL3	poliovirus receptor-related 3
205966	25945	hCG1779876.3	PVRL3	poliovirus receptor-related 3

DOI: 10.3324/haematol.2010.026740

147263	81607	hCG20851.3	PVRL4	poliovirus receptor-related 4
176505	125950	hCG2033729	RAVER1	null
154699	57333	hCG1998059	RCN3	reticulocalbin 3, EF-hand calcium binding domain
167300	6091	hCG1998935	ROBO1	roundabout, axon guidance receptor, homolog 1 (Drosophila)
111044	6092	hCG1735047.2	ROBO2	roundabout, axon guidance receptor, homolog 2 (Drosophila)
200710	64221	hCG2032644	ROBO3	roundabout, axon guidance receptor, homolog 3 (Drosophila)
162644	375056|440751	hCG25333.3	RP11-378J18.4|LO(	null
172499	9092	hCG23307.2	SART1	squamous cell carcinoma antigen recognised by T cells
154411	90198	hCG1810760.1	SBP1	null
120783	80274	hCG40486.2	SCUBE1	signal peptide, CUB domain, EGF-like 1
138127	57758	hCG23893.3	SCUBE2	signal peptide, CUB domain, EGF-like 2
113261	222663	hCG1779807.4	SCUBE3	signal peptide, CUB domain, EGF-like 3
209676	6383	hCG15745.3	SDC2	syndecan 2 (heparan sulfate proteoglycan 1, cell surface-associated, fibroglycan)
217147	6385	hCG38363.2	SDC4	syndecan 4 (amphiglycan, ryudocan)
129059	221935	hCG2036979	SDK1	sidekick homolog 1 (chicken)
175369	221935	hCG2036979	SDK1	sidekick homolog 1 (chicken)
184063	221935	hCG2036979	SDK1	sidekick homolog 1 (chicken)
196537	221935	hCG2036979	SDK1	sidekick homolog 1 (chicken)
231806	221935	hCG1991810	SDK1	sidekick homolog 1 (chicken)
234955	221935	hCG2036979	SDK1	sidekick homolog 1 (chicken)
123088	54549	hCG28994.2	SDK2	sidekick homolog 2 (chicken)
232979	54549	hCG1986151	SDK2	sidekick homolog 2 (chicken)
199263	6401	hCG38008.3	SELE	selectin E (endothelial adhesion molecule 1)
192488	6402	hCG37088.3	SELL	selectin L (lymphocyte adhesion molecule 1)
199831	6402	hCG37088.3	SELL	selectin L (lymphocyte adhesion molecule 1)
114371	6403	hCG38007.3	SELP	selectin P (granule membrane protein 140kDa, antigen CD62)
108579	56920	hCG42589.3	SEMA3G	sema domain, immunoglobulin domain (Ig), short basic domain, secreted, (semaphorin) 3G
117418	54910	hCG18643.3	SEMA4C	sema domain, immunoglobulin domain (Ig), transmembrane domain (TM) and short cytoplasmic domain, (semaphorin) 4C
169984	6414	hCG37243.3	SEPP1	selenoprotein P, plasma, 1
125513	89790	hCG1641285.3	SIGLEC10	sialic acid binding Ig-like lectin 10
194422	114132	hCG1994381	SIGLEC11	sialic acid binding Ig-like lectin 11
126953	89858	hCG1772239.3	SIGLEC12	sialic acid binding Ig-like lectin 12
160405	8778	hCG91954.2	SIGLEC5	sialic acid binding Ig-like lectin 5
151173	946	hCG91955.3	SIGLEC6	sialic acid binding Ig-like lectin 6
139438	27036	hCG19683.3	SIGLEC7	sialic acid binding Ig-like lectin 7
198707	27036	hCG19683.3	SIGLEC7	sialic acid binding Ig-like lectin 7
179941	27181	hCG1647525.3	SIGLEC8	sialic acid binding Ig-like lectin 8
101499	27180	hCG22939.2	SIGLEC9	sialic acid binding Ig-like lectin 9
122182	284367	hCG1772127.3	SIGLECP3	sialic acid binding Ig-like lectin, pseudogene 3
121015	6504	hCG20854.2	SLAMF1	signaling lymphocytic activation molecule family member 1
142444	114836	hCG1766501.2	SLAMF6	SLAM family member 6
135333	57823	hCG20853.3	SLAMF7	SLAM family member 7
152820	57823	hCG20853.3	SLAMF7	SLAM family member 7

DOI: 10.3324/haematol.2010.026740

110971	56833	hCG38209.3	SLAMF8	SLAM family member 8
177405	89886	hCG39737.2	SLAMF9	SLAM family member 9
223460	29015	hCG39762.3	SLC43A3	solute carrier family 43, member 3
127861	6585	hCG25785.4	SLIT1	slit homolog 1 (Drosophila)
109598	9353	hCG1811769.1	SLIT2	slit homolog 2 (Drosophila)
107128	6586	hCG36986.3	SLIT3	slit homolog 3 (Drosophila)
222823	6614	hCG39260.3	SN	sialoadhesin
163087	25992	hCG2013435	SNED1	sushi, nidogen and EGF-like domains 1
162363	10418	hCG1811032.3	SPON1	spondin 1, extracellular matrix protein
169526	10417	hCG34446.2	SPON2	spondin 2, extracellular matrix protein
198631	23145	hCG16180.3	SSPO	SCO-spondin homolog (Bos taurus)
217311	23145	hCG2039182.1	SSPO	SCO-spondin homolog (Bos taurus)
163213	23166	hCG17560.3	STAB1	stabilin 1
120080	55576	hCG1781889.2	STAB2	stabilin 2
201388	161497	hCG2038916|hCG2	STRC	stereocilin
132944	252983	null	STXBP4	syntaxin binding protein 4
143717	6892	hCG17519.4	TAPBP	TAP binding protein (tapasin)
105274	55080	hCG2039662	TAPBPL	TAP binding protein-like
161192	146771	hCG1749492.3	TCAM1	testicular cell adhesion molecule 1 homolog (mouse)
119853	7007	hCG16247.2	TECTA	tectorin alpha
133906	7045	hCG41400.2	TGFBI	transforming growth factor, beta-induced, 68kDa
179403	91937	hCG15399.2	TIMD4	T-cell immunoglobulin and mucin domain containing 4
181072	7082	hCG27621.4	TJP1	tight junction protein 1 (zona occludens 1)
157389	9414	hCG30538.4	TJP2	tight junction protein 2 (zona occludens 2)
182089	27134	hCG1811319.3	TJP3	tight junction protein 3 (zona occludens 3)
187182	53345	hCG38579.4|hCG2(	TM6SF2	transmembrane 6 superfamily member 2
189141	388364	null	TMIGD	transmembrane and immunoglobulin domain containing
143831	3371	hCG29852.3	TNC	tenascin C (hexabrachion)
165227	7130	hCG41965.2	TNFAIP6	tumor necrosis factor, alpha-induced protein 6
176766	63923	hCG24200.3	TNN	tenascin N
208332	7143	hCG24199.3	TNR	tenascin R (restrictin, janusin)
123185	7148	hCG2001565	TNXB	tenascin XB
230136	7148	hCG2001563	TNXB	tenascin XB
110510	6955	hCG1793998.3	TRA@	T cell receptor alpha locus
150469	28738|28517|287	hCG2014112.1	TRAJ17|TRDV2|TR/	T cell receptor alpha joining 17|T cell receptor delta variable 2|T cell receptor alpha constant|T cell receptor alpha variable 20|T cell receptor alpha locus
205345	28663	hCG1812119.2	TRAV20	T cell receptor alpha variable 20
176062	28663|6955	hCG1812143.2	TRAV20|TRA@	T cell receptor alpha variable 20|T cell receptor alpha locus
122565	28639	hCG1686192.2	TRBC1	T cell receptor beta constant 1
169877	28639	hCG1644527.4	TRBC1	T cell receptor beta constant 1
146651	28568	hCG2039505	TRBV19	T cell receptor beta variable 19
111840	28619	hCG2039498	TRBV3-1	T cell receptor beta variable 3-1
191844	28611	hCG2039491	TRBV5-4	T cell receptor beta variable 5-4
165497	28517	hCG2014123.1	TRDV2	T cell receptor delta variable 2

DOI: 10.3324/haematol.2010.026740

106461	10103	hCG22089.3	TSPAN1	tetraspanin 1
174406	83882	hCG1723929.2	TSPAN10	tetraspanin 10
214516	441631	hCG2009527.1	TSPAN11	tetraspanin 11
229054	441631	hCG2009527.1	TSPAN11	tetraspanin 11
215171	23554	hCG33045.3	TSPAN12	tetraspanin 12
197801	81619	hCG23736.4	TSPAN14	tetraspanin 14
166195	23555	hCG23073.2	TSPAN15	tetraspanin 15
192403	26526	hCG29960.2	TSPAN16	tetraspanin 16
153433	26262	hCG41598.3	TSPAN17	tetraspanin 17
204877	10099	hCG40797.3	TSPAN3	tetraspanin 3
181736	340348	hCG41659.4	TSPAN33	tetraspanin 33
144660	7106	hCG1993430	TSPAN4	tetraspanin 4
232203	7106	hCG1994788	TSPAN4	tetraspanin 4
203573	10098	hCG37727.3	TSPAN5	tetraspanin 5
137449	7105	hCG19468.3	TSPAN6	tetraspanin 6
171247	7102	hCG18324.3	TSPAN7	tetraspanin 7
116150	7103	hCG25408.4	TSPAN8	tetraspanin 8
176153	10867	hCG2002355.1	TSPAN9	tetraspanin 9
208640	10867	hCG2040014	TSPAN9	tetraspanin 9
179329	7305	hCG23571.3	TYROBP	TYRO protein tyrosine kinase binding protein
103169	284415	hCG1802988.1	UNQ3033	null
193263	7399	hCG1782692.1	USH2A	Usher syndrome 2A (autosomal recessive, mild)
218015	7399	hCG2042552	USH2A	Usher syndrome 2A (autosomal recessive, mild)
219772	7399	hCG1985824	USH2A	Usher syndrome 2A (autosomal recessive, mild)
220783	7399	hCG1985824	USH2A	Usher syndrome 2A (autosomal recessive, mild)
224218	7399	hCG1985824	USH2A	Usher syndrome 2A (autosomal recessive, mild)
225858	7399	hCG2036693	USH2A	Usher syndrome 2A (autosomal recessive, mild)
226354	7399	hCG1985824	USH2A	Usher syndrome 2A (autosomal recessive, mild)
233814	7399	hCG23154.2	USH2A	Usher syndrome 2A (autosomal recessive, mild)
123908	7412	hCG32384.3	VCAM1	vascular cell adhesion molecule 1
174652	8875	hCG21460.3	VNN2	vanin 2
170786	7441	hCG32561.2	VPREB1	pre-B lymphocyte gene 1
177212	29802	hCG41096.2	VPREB3	pre-B lymphocyte gene 3
147224	340547	hCG1998508.1	VSIG1	V-set and immunoglobulin domain containing 1
177241	23584	hCG39803.2	VSIG2	V-set and immunoglobulin domain containing 2
102138	388078	hCG1812074.1	VSIG6	V-set and immunoglobulin domain containing 6
193279	7448	hCG31810.2	VTN	vitronectin (serum spreading factor, somatomedin B, complement S-protein)
172273	64856	hCG1995870	VWA1	von Willebrand factor A domain containing 1
147927	340706	null	VWA2	von Willebrand factor A domain containing 2
221463	340706	null	VWA2	von Willebrand factor A domain containing 2
126761	7450	hCG2002012	VWF	von Willebrand factor
168882	7483	hCG42240.3	WNT9A	wingless-type MMTV integration site family, member 9A
158336	7484	hCG27973.4	WNT9B	wingless-type MMTV integration site family, member 9B
188020	7455	hCG20463.3	ZAN	zonadhesin
221153	7455	hCG20463.3	ZAN	zonadhesin

DOI: 10.3324/haematol.2010.026740

133751	22917	hCG40396.2	ZP1	zona pellucida glycoprotein 1 (sperm receptor)
183592	7783	hCG38242.2	ZP2	zona pellucida glycoprotein 2 (sperm receptor)
141572	7784	hCG41358.4	ZP3	zona pellucida glycoprotein 3 (sperm receptor)
210665	57829	hCG24865.3	ZP4	zona pellucida glycoprotein 4

DOI: 10.3324/haematol.2010.026740

Supplementaty Table 2: forward and reverse primers designed for RQ-PCR experiments

Gene	Forward 5'→3'	Reverse 5'→3'
TSP-1	CCACTGCTACTGGGACACCAA	TGTGGTGGAGTTTACAACTTTCACA
vWF	CCCTGGGTTACAAGGAAGAAAAT	AGTGTCATGATCTGTCCTCCTCTTAG
PECAM-1	CCACTGAAGACGTCGAATACCA	CTATCACCTTCACCCTCAGAACC
CD36	GCAAAATCCACAGGAAGTGATG	GCTAGAAAACGAACTCTGTACGTATAAGG
TBP	CACGAACCACGGCACTGATT	TTTTCTTGCTGCCAGTCTGGAC

DOI: 10.3324/haematol.2010.026740

Accession Number
NM003246
NM000552
NM000442
BC008406
Y02584

DOI: 10.3324/haematol.2010.026740

Supplementary Table 3: HC modulated genes of the "Adhesion" data sets after 24h of treatment under basal conditions (Common genes for both 24 and 48h of treatment are underlined in grey)

PROBE	LOG_fold change	Gene_Symbol	Gene_Name
195222	5.87490	ADAM12	ADAM metallopeptidase domain 12 (meltrin alpha)
212524	2.40830	ADAMTS4	ADAM metallopeptidase with thrombospondin type 1 motif, 4
209820	3.42530	CD86	CD86 antigen (CD28 antigen ligand 2, B7-2 antigen)
185528	2.68320	CLDN8	claudin 8
202592	-2.47860	CLEC14A	C-type lectin domain family 14, member A
219504	-2.41560	COL1A1	collagen, type I, alpha 1
113262	-1.52710	COL3A1	collagen, type III, alpha 1 (Ehlers-Danlos syndrome type IV, autosomal dominant)
111306	-2.55670	COL4A2	collagen, type IV, alpha 2
110570	-1.16300	COL5A1	collagen, type V, alpha 1
190250	-1.40000	CTA-246H3.1	null
200724	-3.19530	DAG1	dystroglycan 1 (dystrophin-associated glycoprotein 1)
162548	-2.49370	EFEMP2	EGF-containing fibulin-like extracellular matrix protein 2
105515	-1.51180	EGFL3	EGF-like-domain, multiple 3
188754	2.13570	FAT4	FAT tumor suppressor homolog 4 (Drosophila)
166297	1.10430	FBLN2	fibulin 2
155212	-2.73110	ICAM2	intercellular adhesion molecule 2
207755	-3.49010	IGFBP4	insulin-like growth factor binding protein 4
164847	3.87130	IGSF11	immunoglobulin superfamily, member 11
160329	-4.10150	ILK	integrin-linked kinase
145228	-3.46970	ITGA5	integrin, alpha 5 (fibronectin receptor, alpha polypeptide)
117740	-1.57220	LAMB1	laminin, beta 1
176679	-1.57990	LAMB2	laminin, beta 2 (laminin S)
180055	-2.46000	LAMC1	laminin, gamma 1 (formerly LAMB2)
197253	-3.04600	LEPRE1	leucine proline-enriched proteoglycan (leprecan) 1
170997	-1.95810	LEPREL2	leprecan-like 2
151835	-0.86940	LGALS1	lectin, galactoside-binding, soluble, 1 (galectin 1)
128091	2.47190	LSAMP	limbic system-associated membrane protein
165409	-3.16730	MCAM	melanoma cell adhesion molecule

DOI: 10.3324/haematol.2010.026740

190435	-1.67850	MGP	matrix Gla protein
146058	-4.16380	MMP2	matrix metallopeptidase 2 (gelatinase A, 72kDa gelatinase, 72kDa type IV collagenase)
128509	-2.79240	MMRN1	multimerin 1
155462	-3.27680	MMRN2	multimerin 2
200980	-3.67230	NID1	nidogen 1
128130	-2.54450	NOTCH2|NOTCH2NL	Notch homolog 2 (Drosophila)|Notch homolog 2 (Drosophila) N-terminal like
133305	2.03320	null	null
145456	2.70930	null	null
187056	3.02170	null	null
124958	2.48350	PCDHA5	protocadherin alpha 5
122279	-2.63660	PEAR1	null
103150	-1.31770	PECAM1	platelet/endothelial cell adhesion molecule (CD31 antigen)
185750	-1.02470	PMF1|BGLAP	polyamine-modulated factor 1|bone gamma-carboxyglutamate (gla) protein (osteocalcin)
200143	-2.28290	PTPRF	protein tyrosine phosphatase, receptor type, F
205966	-2.58030	PVRL3	poliovirus receptor-related 3
176505	-2.56930	RAVER1	null
172499	-1.74710	SART1	squamous cell carcinoma antigen recognised by T cells
223460	-3.21350	SLC43A3	solute carrier family 43, member 3
133906	-1.44350	TGFBI	transforming growth factor, beta-induced, 68kDa
162911	-4.49700	THBS1	thrombospondin 1
122565	2.72360	TRBC1	T cell receptor beta constant 1
197801	-0.95660	TSPAN14	tetraspanin 14
204877	-2.17500	TSPAN3	tetraspanin 3
116150	-0.79040	TSPAN8	tetraspanin 8
126761	-3.24220	VWF	von Willebrand factor

DOI: 10.3324/haematol.2010.026740

Supplementary Table 4: HC modulated genes of the "Adhesion" data sets after 48h of treatment under basal conditions (Common genes for both 24 and 48h of treatment are underlined in grey)

PROBE	LOG_fold chang	Gene_Symbol	Gene_Name
216353	-1.09140	ADAMTS1	ADAM metallopeptidase with thrombospondin type 1 motif, 1
212524	1.09680	ADAMTS4	ADAM metallopeptidase with thrombospondin type 1 motif, 4
224751	-1.17480	ALS2CR19	amyotrophic lateral sclerosis 2 (juvenile) chromosome region, candidate 19
217924	0.90900	BOMB	null
173181	2.89150	CEACAM1	carcinoembryonic antigen-related cell adhesion molecule 1 (biliary glycoprotein)
219223	3.02930	CEACAM1	carcinoembryonic antigen-related cell adhesion molecule 1 (biliary glycoprotein)
155501	1.58380	CLSTN3	calsyntenin 3
181713	-1.09990	COL13A1	collagen, type XIII, alpha 1
141012	-0.72780	COL18A1	collagen, type XVIII, alpha 1
158495	1.17570	DDR2	discoidin domain receptor family, member 2
101210	-1.09980	EFEMP1	EGF-containing fibulin-like extracellular matrix protein 1
182608	1.49300	F11R	F11 receptor
131558	0.65200	FAT	FAT tumor suppressor homolog 1 (Drosophila)
166297	-0.84350	FBLN2	fibulin 2
147111	-0.70260	FBN1	fibrillin 1 (Marfan syndrome)
484021	0.76050	FCGR3B|FCGR3	Fc fragment of IgG, low affinity IIIb, receptor (CD16b)|Fc fragment of IgG, low affinity IIIa, receptor (CD16a)
168389	1.79890	FCHO2	FCH domain only 2
205205	-0.65960	FURIN	furin (paired basic amino acid cleaving enzyme)
109070	2.35060	ICAM1	intercellular adhesion molecule 1 (CD54), human rhinovirus receptor
150353	2.32060	IGFBP6	insulin-like growth factor binding protein 6
223442	1.43090	ITGA2	integrin, alpha 2 (CD49B, alpha 2 subunit of VLA-2 receptor)
137521	-0.71070	ITGAE	integrin, alpha E (antigen CD103, human mucosal lymphocyte antigen 1; alpha polypeptide)
117958	1.42940	ITGAV	integrin, alpha V (vitronectin receptor, alpha polypeptide, antigen CD51)
187625	1.00540	ITGB1	integrin, beta 1 (fibronectin receptor, beta polypeptide, antigen CD29 includes MDF2, MSK12)
109549	2.72430	KITLG	KIT ligand
201627	1.55800	LAMC2	laminin, gamma 2
185853	2.55260	LGALS3BP	lectin, galactoside-binding, soluble, 3 binding protein
151391	0.89980	LGALS8	lectin, galactoside-binding, soluble, 8 (galectin 8)
119769	-1.09760	LTBP1	latent transforming growth factor beta binding protein 1
116441	-1.08900	LTBP2	latent transforming growth factor beta binding protein 2
165409	1.58310	MCAM	melanoma cell adhesion molecule
213008	0.89020	MFAP1	microfibrillar-associated protein 1
121617	-1.70750	MGP	matrix Gla protein
206371	0.94860	MPZL1	myelin protein zero-like 1

DOI: 10.3324/haematol.2010.026740

128130	1.24430	NOTCH2|NOTC	Notch homolog 2 (Drosophila)|Notch homolog 2 (Drosophila) N-terminal like
185137	1.31310	NTN4	netrin 4
105086	0.95890	null	null
116092	-0.98350	PCDH10	protocadherin 10
209182	-1.32320	PCDHGB5|PCDI	protocadherin gamma subfamily B, 5|protocadherin gamma subfamily C, 3|protocadherin gamma subfamily A, 8|protocadherin gamma subfamily C, 5|protocadherin gamma subfamily B, 3|protocadherin gamma subfamily B, 1|protocadherin gamma subfamily A, 2|protocadherin gamma subfamily A, 5|protocadherin gamma subfamily B, 6|protocadherin gamma subfamily B, 4|protocadherin gamma subfamily B, 7|protocadherin gamma subfamily A, 6|protocadherin gamma subfamily B, 2|protocadherin gamma subfamily A, 10|protocadherin gamma subfamily A, 3|protocadherin gamma subfamily A, 4|protocadherin gamma subfamily A, 11|protocadherin gamma subfamily A, 9|protocadherin gamma subfamily A, 7|protocadherin gamma subfamily C, 4|protocadherin gamma subfamily A, 12|protocadherin gamma subfamily A, 1
141903	-0.66600	PCOLCE2	procollagen C-endopeptidase enhancer 2
103150	-1.20420	PECAM1	platelet/endothelial cell adhesion molecule (CD31 antigen)
130276	-0.92160	PSG9	pregnancy specific beta-1-glycoprotein 9
141843	1.53220	PSTPIP2	proline-serine-threonine phosphatase interacting protein 2
149750	1.59160	PVR	poliovirus receptor
217147	1.30470	SDC4	syndecan 4 (amphiglycan, ryudocan)
223460	1.02030	SLC43A3	solute carrier family 43, member 3
143717	0.90010	TAPBP	TAP binding protein (tapasin)
204877	1.49330	TSPAN3	tetraspanin 3
116150	-1.13390	TSPAN8	tetraspanin 8

DOI: 10.3324/haematol.2010.026740

Supplementary Table 5 : HC modulated genes of the "Adhesion" data sets after 24h of treatment under pro-inflammatory conditions (Common genes for both 24 and 48h of treatment are underlined in grey)

PROBE	LOG_fold change	Gene_Symbol	Gene_Name
216353	-0.79370	ADAMTS1	ADAM metallopeptidase with thrombospondin type 1 motif, 1
212524	1.17620	ADAMTS4	ADAM metallopeptidase with thrombospondin type 1 motif, 4
220229	-2.21240	ASGR1	asialoglycoprotein receptor 1
173181	0.72190	CEACAM1	carcinoembryonic antigen-related cell adhesion molecule 1 (biliary glycoprotein)
219504	-0.70300	COL1A1	collagen, type I, alpha 1
114784	-0.64990	COL5A2	collagen, type V, alpha 2
135619	-0.70740	CREBL1|TNXB	cAMP responsive element binding protein-like 1|tenascin XB
707818	-0.66900	DCN	decorin
142663	0.62890	DLG5	discs, large homolog 5 (Drosophila)
220221	0.79680	EGFL3	EGF-like-domain, multiple 3
133498	1.02450	FCRL5	Fc receptor-like 5
261063	-0.64140	GJB7	gap junction protein, beta 7
109070	0.81390	ICAM1	intercellular adhesion molecule 1 (CD54), human rhinovirus receptor
155212	1.12550	ICAM2	intercellular adhesion molecule 2
184949	-0.66920	IGHD	immunoglobulin heavy constant delta
145228	0.72050	ITGA5	integrin, alpha 5 (fibronectin receptor, alpha polypeptide)
162965	-0.67920	LTBP4	latent transforming growth factor beta binding protein 4
190435	-0.68120	MGP	matrix Gla protein
152076	-0.68610	MMP14	matrix metallopeptidase 14 (membrane-inserted)
111229	-2.14390	MMP27	matrix metallopeptidase 27
145989	-0.81220	MUC4	mucin 4, tracheobronchial
219954	1.11270	NPNT	nephronectin
533601	-0.76110	null	null
643635	-0.83140	null	null
708536	-1.02950	null	null
147844	0.88320	PCDHA7	protocadherin alpha 7
544276	-0.88920	PCDHB18	protocadherin beta 18 pseudogene
117418	-0.68250	SEMA4C	sema domain, immunoglobulin domain (Ig), transmembrane domain (TM) and short cytoplasmic domain, (semaphorin) 4C
511171	0.69870	SSPO	SCO-spondin homolog (Bos taurus)
162911	-0.83140	THBS1	thrombospondin 1
144660	-0.97650	TSPAN4	tetraspanin 4
116150	-0.73050	TSPAN8	tetraspanin 8
123908	-0.83210	VCAM1	vascular cell adhesion molecule 1

DOI: 10.3324/haematol.2010.026740

Supplementary Table 6: HC modulated genes of the "Adhesion" data sets after 48h of treatment under pro-inflammatory conditions (Common genes for both 24 and 48h of treatment are underlined in grey)

PROBE	LOG_Q[HC48_	Gene_Symbol	Gene_Name
216353	-0.93070	ADAMTS1	ADAM metallopeptidase with thrombospondin type 1 motif, 1
212524	1.03150	ADAMTS4	ADAM metallopeptidase with thrombospondin type 1 motif, 4
162273	-1.00200	CCBE1	collagen and calcium binding EGF domains 1
155853	-1.32970	CLDN11	claudin 11 (oligodendrocyte transmembrane protein)
202592	-1.00360	CLEC14A	C-type lectin domain family 14, member A
113262	-1.39580	COL3A1	collagen, type III, alpha 1 (Ehlers-Danlos syndrome type IV, autosomal dominant)
114784	-0.61710	COL5A2	collagen, type V, alpha 2
222934	-0.88560	COL8A1	collagen, type VIII, alpha 1
101210	-0.65240	EFEMP1	EGF-containing fibulin-like extracellular matrix protein 1
133221	-0.60840	ESAM	endothelial cell adhesion molecule
112884	-1.08330	FCER1G	Fc fragment of IgE, high affinity I, receptor for; gamma polypeptide
109549	0.94940	KITLG	KIT ligand
217099	0.64550	LIN7C	lin-7 homolog C (C. elegans)
155462	-0.65610	MMRN2	multimerin 2
116092	-0.68040	PCDH10	protocadherin 10
103150	-0.77850	PECAM1	platelet/endothelial cell adhesion molecule (CD31 antigen)
141843	0.66290	PSTPIP2	proline-serine-threonine phosphatase interacting protein 2
205966	-0.73410	PVRL3	poliovirus receptor-related 3
162911	-1.33260	THBS1	thrombospondin 1
165227	1.15860	TNFAIP6	tumor necrosis factor, alpha-induced protein 6
116150	-1.03980	TSPAN8	tetraspanin 8