Induction of Maturation and Cytokine Release of Human Dendritic Cells by *Helicobacter pylori*

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*Helicobacter pylori* causes a persistent infection in the human stomach, which can result in chronic gastritis and peptic ulcer disease. Despite an intensive proinflammatory response, the immune system is not able to clear the organism. However, the immune escape mechanisms of this common bacterium are not well understood. We investigated the interaction between *H. pylori* and human dendritic cells. Dendritic cells (DCs) are potent antigen-presenting cells and important mediators between the innate and acquired immune system. Stimulation of DCs with different concentrations of *H. pylori* for 8, 24, 48, and 72 h resulted in dose-dependent interleukin-6 (IL-6), IL-8, IL-10, and IL-12 production. Lipopolysaccharide (LPS) from *Escherichia coli*, a known DC maturation agent, was used as a positive control. The cytokine release after stimulation with LPS was comparable to that induced by *H. pylori* except for IL-12. After LPS stimulation IL-12 was only moderately released compared to the large amounts of IL-12 induced by *H. pylori*. We further investigated the potential of *H. pylori* to induce maturation of DCs. Fluorescence-activated cell sorting analysis of cell surface expression of maturation marker molecules such as CD80, CD83, CD86, and HLA-DR revealed equal upregulation after stimulation with *H. pylori* or LPS. We found no significant differences between *H. pylori* seropositive and seronegative donors of DCs with regard to cytokine release and upregulation of surface molecules. These data clearly demonstrate that *H. pylori* induces a strong activation and maturation of human immature DCs.

*Helicobacter pylori* is a gastric pathogenic gram-negative bacterium that colonizes the gastric mucus layer but does not invade the mucosal epithelium. This bacterial colonization leads to a cellular infiltrate of polymorphonuclear leukocytes, an acute immune response, followed by the migration of macrophages, lymphocytes, and plasma cells in the gastric mucosa, resulting in chronic gastritis. This chronic inflammation does not necessarily produce symptoms but does increase the risk of developing peptic ulcer disease, adenocarcinoma of the distal stomach (antrum and fundus), and primary non-Hodgkin’s lymphoma of the stomach (MALTomas) (8, 42, 43).

Although *H. pylori* induces an immune response involving both the innate and the acquired immune systems, the host is unable to clear the organism from the mucosa, resulting in lifelong infection. This inability to eliminate the bacterium may be due to immune- evade strategies. Possible mechanisms were investigated, with emphasis on the acquired immune response. Several studies have shown inhibitory effects of *H. pylori* on cell proliferation (11, 24–26, 60), and the induction of *H. pylori*-specific regulatory T cells that actively suppress T-cell response have been described (31).

Recent studies have investigated possible impairment of antigen presentation (38). Other studies showed that *H. pylori* induced inhibition of phagocytosis by professional phagocytes involving cag-PAI (pathogenicity island), a type IV secretion system (44).

Although several studies investigated the interaction between *H. pylori* and the innate immunity (9, 17, 21, 24, 35, 56), little is known about the influence of *H. pylori* on dendritic cells (DCs), especially in the human immune system (14, 59). DCs are central mediators between the innate and adaptive immune system and play an important role in capturing, processing, and presenting antigens (5, 6). The process of differentiation from an immature DC into a mature professional antigen-presenting cell (APC) can be induced by whole bacteria or their components, pathogen-associated molecular patterns. This process is accompanied by upregulation of major histocompatibility complex (MHC) classes I and II, costimulatory molecules such as CD80, CD83, and CD86, and adhesion molecules such as CD54 (6, 13), together with cytokine production (10, 58).

DCs are found in almost all tissues, including the gastrointestinal mucosa. Here they are capable of opening the tight junctions that enable them to interact directly with bacteria on the mucosal layer (45, 49). Moreover, recent studies have shown the potential of *H. pylori* to disrupt the epithelial apical-junctional complex (1), which would increase the probability for DCs to get into direct contact with the bacteria. These findings make a direct interaction between *H. pylori* and mucosal DCs in vivo very likely, resulting in (i) activation, maturation, and differentiation of DCs and (ii) phagocytosis, processing, and presenting of *H. pylori* antigen to antigen-specific T lymphocytes.
Different scenarios may explain this interaction. *H. pylori* induces activation, maturation, and cytokine release via the Toll-like receptor 2 (TLR2), TLR4, and TLR5 (23, 51, 57), or *H. pylori* induces perturbation of DC function via inhibitory mechanisms described earlier (26). The latter would result in an impairment of clonal *H. pylori*-specific T-cell proliferation and the persistence of infection.

Thus, the purpose of the present study was to evaluate the effect of *H. pylori* on the activation and maturation of human DCs. The data presented demonstrate that *H. pylori* induces IL-10, IL-12, IL-6, and IL-8 secretion, as well as upregulation of costimulatory molecules such as CD80, CD83, CD86, and HLA-DR in human immature DCs independent of the *H. pylori* serostatus of the donor.

**MATERIALS AND METHODS**

*H. pylori* serology. Serum samples from each healthy donor were obtained and screened for the presence of immunoglobulin G antibody titers to *H. pylori* by using a commercial enzyme-linked immunosorbent assay (ELISA; Behring, Marburg, Germany).

Cell culture. Monocytes were isolated by leukapheresis of healthy donors, subsequent Ficoll-Hypaque density gradient centrifugation, and countercurrent elutriation in a J6 M-E centrifuge (Beckman, Munich, Germany) as previously described (27). Monocytes were >99% pure as determined by flow cytometry (data not shown). Immature monocyte-derived DCs were generated by culturing elutriated monocytes in complete RPMI 1640 (Biochrom KG, Berlin, Germany) containing 5% fetal calf serum, vitamins, pyruvate, and nonessential amino acids (all from Life Technologies, Karlsruhe, Germany), 5 × 10^{-8} M β-mercaptoethanol, 500 U of rhIL-4 (Schering-Plough, Bloomfield, N.J., or Promocell, Heidelberg, Germany)/ml, and recombinant human granulocyte-macrophage colony-stimulating factor (rhGM-CSF; Essex, Munich, Germany) as described previously (27). On day 3 additional 250 U each of rhIL-4 and rhGM-CSF/ml was routinely determined by FACS Epics XL MCL flow cytometer (Beckman-Coulter).

Statistical analysis. Results shown graphically are from a single representative experiment expressed as the mean ± the standard deviation of the mean, calculated using aliquots from the same donor. In all, DCs from six seronegative donors and five seropositive donors were investigated in the present study. The data were analyzed by using the nonparametric Friedman test for multiple comparisons (PBS versus LPS and *H. pylori*). For analysis of seropositive and seronegative donors, the nonparametric Mann-Whitney test was used. *P* values of <0.05 were considered significant.

**RESULTS**

*H. pylori* induces dose-dependent cytokine secretion from immature DCs. Immature DCs were generated and stimulated with *H. pylori* for 24 h at different MOIs ranging from 0.01 to 100. LPS at a concentration of 100 ng/ml was used as a known DC activation stimulus. After incubation, supernatants were collected and storage at -20°C until assayed. IL-6, IL-8, IL-12, and IL-12 were determined from culture supernatants by ELISA with commercial available assay kits (Becton Dickinson) according to standard procedures. In these assays, the lower limits of detection were 4.7 pg/ml for IL-6, 3.1 pg/ml for IL-8, 7.8 pg/ml for IL-10, and 7.8 pg/ml for IL-12.

**FACS analysis.** For fluorescence-activated cell sorting (FACS) analysis, 2.5 × 10^5 DCs were resuspended in 100 µl of PBS containing 1% fetal calf serum and 0.1% sodium azide (Merck, Darmstadt, Germany) (FACS buffer) and incubated with 4 µl of the appropriate fluorescein isothiocyanate- and/or phycoerythrin-labeled antibody (Becton Dickinson or Beckman-Coulter, Krefeld, Germany) for 20 min on ice in the dark. Cells were then washed twice with 2 ml of FACS buffer and resuspended in 500 µl of PBS supplemented with 5% of paraformaldehyde (Sigma-Aldrich). Cell death was determined by adding propidium iodide (Sigma-Aldrich) to cell suspensions at a final concentration of 0.5 µg/ml prior to flow cytometric analysis. Analysis was performed with Coulter Epics XL MCL flow cytometer (Beckman-Coulter).

**FIG. 1.** Surface phenotype of immature DCs as determined by flow cytometry. Cells were stained with fluorescence-conjugated monoclonal antibodies prior to stimulation (open curve, isotype control; shaded curve, specific staining). Immature DCs expressed high levels of CD1a (isotype-correlated median [med] = 1,851), HLA-DR (med = 156), and low levels of CD80 (med = 6), and CD86 (med = 4). CD14 expression was markedly downregulated (med = 13) compared to freshly isolated monocytes (med = 510 [data not shown]).
of 100 (data not shown). These results strongly suggest that superphysiological high concentrations of *H. pylori* have a toxic effect. Increasing IL-8 levels in culture supernatants at superphysiological bacterial concentrations (Fig. 2D) could be explained with: (i) cell lyses and consequential cytokine release or (ii) cell death, which itself induces IL-8 release in the remaining viable cells (29). In contrast, IL-12, IL-10, and IL-6 release depends on cell vitality, as cytokine production decreases and cell death increases with MOIs of >10.

Cytokine production was detectable at an MOI of 0.01 (ca. 9,593 pg/ml for IL-6 and 1,333 pg/ml for IL-8). These results show that one bacterium per 100 cells is sufficient to induce DC activation and that activation is dose dependent. *H. pylori* and LPS were almost equally potent in inducing DC activation. Only for IL-12 did we find a significant difference in cytokine production between *H. pylori* and LPS. LPS induced moderate amounts of IL-12 (194 to 3,335 pg/ml) compared to *H. pylori* (8,224 to 319,000 pg/ml) (Table 1). The absolute amounts of cytokines produced from different donors in response to stimulation with *H. pylori* or LPS varied widely. For further experiments, we considered an MOI of 10 to be the optimal dose for DC stimulation.

**Kinetics of cytokine production in immature DCs after stimulation with *H. pylori***. After determining the optimal bacterial dose for DC activation, we were interested in studying the kinetics of cytokine production by DCs stimulated with *H. pylori*. We used *H. pylori* at an MOI of 10 and LPS at a concentration of 100 ng/ml. IL-8 and IL-6 were detectable as soon as 4 h after stimulation with *H. pylori* and LPS (data not shown). Stimulation for 8 h induced high amounts of IL-6 and IL-8. IL-6 levels increased during the subsequent 24 h when they reached a plateau, whereas IL-8 production increased considerably during the complete stimulation period (Fig. 3C and 3D). IL-10 secretion started after 6 h and increased until 48 h, when it reached a maximum, and decreased slightly during the following 24 h of stimulation (Fig. 3A). The kinetics for IL-12 production were similar except that it was first detected after 8 to 10 h (Fig. 3B). Comparable kinetics of cytokine production were observed for stimulation with *H. pylori* and LPS.

**H. pylori induces expression of differentiation and maturation markers on immature DCs**. The potential of *H. pylori* to induce DC maturation was investigated by stimulating immature DCs with *H. pylori* at an MOI of 10 or with LPS (100 ng/ml). After 72 h, the expression of CD80, CD83, CD86, and HLA-DR was determined by FACS analysis. The mean fluorescence intensity (MFI) for CD80, a costimulatory molecule for T-cell activation, was significantly increased by stimulation with *H. pylori* compared to basal expression (Fig. 4A). Stimulation with LPS, a known and well-described maturation agent for DCs, showed a significant increase in the MFI for CD80. In addition, the costimulatory
molecules CD83 and CD86 were upregulated by stimulation with *H. pylori*, as well as with LPS, compared to the basal expression (Fig. 4B and C). MHC class II molecules are upregulated during the maturation process of immature DCs. Processed antigens are presented in the form of MHC class II peptide complexes on the cell surface and recognized by CD4 cells. Therefore, increased expression of MHC class II molecules is important for the interaction between innate and adaptive immunity. Stimulation with *H. pylori* showed a significant upregulation of MHC class II molecules (HLA-DR) on DC surfaces, as did LPS (Fig. 4D).

*H. pylori*-induced activation and maturation of immature DCs is independent of the serostatus. We found cytokine response to be independent of the serostatus when we examined DCs from various seropositive and negative donors (Table 1). The absolute amounts of cytokine production and the susceptibility for LPS and *H. pylori* varied considerably between different donors. We did not detect any significant differences in cytokine responses for IL-6, IL-8, and IL-10 between DCs stimulated with *H. pylori* or LPS. In contrast to the observed low to moderate amounts of IL-12 induced by LPS, *H. pylori* always stimulated high levels of IL-12 release (*P* = 0.001). These data are in accordance with results presented above (Fig. 2B and 3B).

As for the cytokines, seropositive and seronegative donors did not show any significant differences regarding the maturation-induced expression of surface molecules (Table 2).

### DISCUSSION

We observed IL-6, IL-10, and IL-12p70 production, as well as IL-8 release, after the stimulation of DCs with *H. pylori*. The cytokine secretion showed distinct kinetics and was dose dependent. These findings conflict with a recent study (14), which reported little IL-6 release, no IL-10 production, and only small amounts of IL-12p70 production (~100 pg/ml) after stimulation with *H. pylori*. Guiney et al. (14) used *Salmonella enterica* containing a highly stimulatory LPS as a positive control. DCs stimulated with *S. enterica* produced large amounts of IL-6 (~100,000 pg/ml). These data are in accordance with the IL-6 production we observed after LPS stimulation. Others have shown that stimulation of DCs with LPS induced IL-10 (3,000 to 36,000 pg/ml), IL-6 (193,000 to 500,000 pg/ml), and IL-12p70 (7,000 to 13,000 pg/ml) at levels comparable to our results (28). These conflicting results regarding cytokine production after DC stimulation might be explained by different DC preparation and stimulation protocols. Guiney et al. (14) isolated monocytes by plastic adherence and differentiated the cells by culturing them for 5 days with 1,000 U of IL-4 and GM-CSF/ml, whereas we used leukapheresis, Ficoll-Hypaque density gradient centrifugation, and countercurrent elution for cell isolation and generated DCs by culturing them for 7 days with 500 U of IL-4 and GM-CSF/ml. We stimulated DCs in 24-well plates at a concentration of 10⁵ DCs/ml compared to Guiney et al., who used only 2 × 10⁵ DCs/well in 24-well plates, which might have resulted in reduced cell-cell interaction and therefore in decreased autocrine stimulation.

Previous studies showed locally increased production of cytokines such as IL-8 and IL-6 in the gastric mucosa (2, 32). IL-8 is a chemokine known to attract neutrophils. IL-6, a proinflammatory cytokine, is an important intermediary in the resolution of inflammation. It supports transition between the early, predominantly neutrophilic stage of an infection and the more sustained mononuclear cell influx. The production of these

### Table 1. DCs from seropositive and seronegative donors stimulated with *H. pylori* release comparable amounts of cytokines

<table>
<thead>
<tr>
<th>Cytokine and serostatus</th>
<th>Donor</th>
<th>Amount of cytokine produced (pg/ml) after treatment with:</th>
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<tbody>
<tr>
<td>IL-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>1</td>
<td>&lt;4.7, 75.988 ± 4.987, 168.000 ± 4.879</td>
</tr>
<tr>
<td>Positive</td>
<td>1</td>
<td>≥&lt;4.7, 75.988 ± 4.987, 168.000 ± 4.879</td>
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<tr>
<td></td>
<td>2</td>
<td>&lt;4.7, 162.000 ± 27.450, 75.200 ± 8.976</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>≥&lt;4.7, 202.000 ± 4.778, 25.580 ± 157</td>
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<tr>
<td></td>
<td>4</td>
<td>&lt;4.7, 66.600 ± 17.670, 114.500 ± 18.280</td>
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<tr>
<td></td>
<td>5</td>
<td>≥&lt;4.7, 69.720 ± 8.841, 150.400 ± 9.068</td>
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<tr>
<td></td>
<td>6</td>
<td>&lt;4.7, 143.100 ± 3.968, 274.300 ± 25.770</td>
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<td>IL-12</td>
<td></td>
<td></td>
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<tr>
<td>Negative</td>
<td>1</td>
<td>&lt;7.8, 1595 ± 260, 57.065 ± 219</td>
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<tr>
<td></td>
<td>2</td>
<td>≥&lt;7.8, 2004 ± 115, 8.224 ± 1024</td>
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<tr>
<td></td>
<td>3</td>
<td>≥&lt;7.8, 262 ± 2, 155.900 ± 35.000</td>
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<tr>
<td></td>
<td>4</td>
<td>≥&lt;7.8, 19 ± 28, 12.300 ± 230</td>
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<td>5</td>
<td>≥&lt;7.8, 3 ± 216, 18.682 ± 375</td>
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<td>6</td>
<td>≥&lt;7.8, 2 ± 126, 26.410 ± 412</td>
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<tr>
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<td>1.4 ± 8, 877 ± 15.284 ± 8.126</td>
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<tr>
<td></td>
<td>2</td>
<td>≥&lt;7.8, 3 ± 1 ± 230 ± 8.126</td>
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<tr>
<td></td>
<td>3</td>
<td>≥&lt;7.8, 73 ± 1, 13 ± 1 ± 230</td>
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<tr>
<td></td>
<td>4</td>
<td>≥&lt;7.8, 416 ± 2, 319 ± 0.4 ± 230</td>
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<tr>
<td></td>
<td>5</td>
<td>≥&lt;7.8, 1 ± 23, 11 ± 4.1 ± 230</td>
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<td>IL-10</td>
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<td>Negative</td>
<td>1</td>
<td>111 ± 6, 3 ± 293 ± 111, 6.347 ± 472</td>
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<td>≥&lt;7.8, 3 ± 293 ± 111, 9.565 ± 267</td>
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<td>≥&lt;7.8, 416 ± 2, 319 ± 0.4 ± 230</td>
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<td>5</td>
<td>≥&lt;7.8, 1 ± 23, 11 ± 4.1 ± 230</td>
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<td>IL-8</td>
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<tr>
<td>Negative</td>
<td>1</td>
<td>1,066 ± 383, 56,980 ± 2,897, 117 ± 5,026</td>
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<td></td>
<td>2</td>
<td>≥ND, 1,066 ± 383, 56,980 ± 2,897</td>
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<tr>
<td></td>
<td>3</td>
<td>≥ND, 543 ± 100, 122,000 ± 1,806, 1218,000 ± 11,920</td>
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<td>4</td>
<td>≥ND, 4 ± 22, 113,000 ± 21 ± 650, 161,400 ± 2,360</td>
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<td>5</td>
<td>≥ND, 107 ± 8, 267,400 ± 19 ± 740, 333 ± 21,340</td>
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<tr>
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<td>6</td>
<td>≥ND, 33 ± 3, 160,200 ± 18,520, 929,300 ± 113,900</td>
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<tr>
<td>Positive</td>
<td>1</td>
<td>1.4 ± 8, 877 ± 15.284 ± 8.126</td>
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<td>≥ND, 1.4 ± 8, 877 ± 15.284</td>
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<td></td>
<td>5</td>
<td>≥ND, 1.4 ± 8, 877 ± 15.284</td>
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* A total of 10⁵ immature monocyte-derived DCs/ml were stimulated with *H. pylori* at a MOI of 10 or with LPS of 100 ng/ml for 24 h. DCs treated with 10 µl of PBS served as an unstimulated control. DCs from six seropositive and five seronegative donors were investigated. Cytokine levels (IL-6, IL-12, and IL-10) were below the cutoff for PBS stimulation in some experiments. For some donors, the IL-8 and IL-10 cytokine levels were not determined (ND). There was a significant difference between *H. pylori* and LPS in inducing IL-12 production (*P* < 0.5).
cytokines in the gastric mucosa correlates with the histological picture of *H. pylori* gastritis, which is a severe inflammation with polymorphonuclear infiltrations (47, 53). Several studies identified gastric epithelial cells as a source of the IL-8 production (18, 39, 41). We showed that DCs secreted IL-8 and IL-6 in response to stimulation with *H. pylori*. Our results suggest that the innate immune system contributes to the production of these cytokines, triggering and modulating the local inflammatory response.

It has been reported that *H. pylori* induces a Th1 response (4, 30, 36). Some studies suggest that a Th2 response to *H. pylori* infection leads to a less severe inflammation or even protects against a persistent infection (37, 52, 54). In considering the Th1 response induced by *H. pylori*, the simultaneous production of IL-12 and IL-10 seems surprising. DCs are divided into DC1 and DC2 according to their ability to induce a Th1 or Th2 response (22, 46). There is evidence that functional differences between APC lineages might contribute to the polarization of Th-cell response (17, 50). Another concept is based on the (tissue- and pathogen-type) context of DC activation, which leads either to a Th1- or Th2-promoting effector function (21). Recently, it was shown that the kinetics of DC activation and migration can influence the type of effector and memory T cells generated (28). That study showed distinct kinetics of cytokine and chemokine production by DCs stimulated with LPS and exhaustion of cytokine production. DC stimulation for 48 h led to exhaustion of cytokine production and switch from Th1- to Th2-inducing mode. These results indicate a flexible and dynamically regulated model of the Th1-Th2 polarizing capacity of DCs.

Our data are in accordance with those in the study by Langenkamp et al. (28). IL-6, IL-8, IL-10, and IL-12 were all present after 8 h of stimulation. IL-6 and IL-8 were detected as soon as 4 h after stimulation. In the case of IL-6 the production reached a plateau after 24 h, whereas IL-8 accumulation increased during the whole time course. The proinflammatory cytokine IL-6 and the chemokine IL-8 released in the early phase of an infection in the peripheral tissue lead to a recruitment of APCs and neutrophils. The kinetics for IL-12 were different. IL-12 was detected after 8 to 10 h and reached a maximum level after 48 h, decreasing slightly during the following 24 h, whereas measurable IL-10 production started after 6 h of stimulation, with a maximum level reached at the 48-h time point. The delayed IL-12 production, however, may coincide with the DC homing in lymph nodes, where IL-12 can influence the DC T-cell interaction. These results, together with the previously described model of the Th1-Th2-inducing capacity of DCs, make it very unlikely that *H. pylori* induces exclusively or even dominantly a Th1 response.

In several studies, however, there is evidence that IL-10 may play a relevant role in the *H. pylori*-induced immune response. IL-10 is important for the generation of type 1 regulatory T cells (Tr-1 cells) (7, 20, 61). Tr-1 cells are defined by their ability to produce high levels of IL-10 and transforming growth factor β. They have a low proliferative capacity and are able to suppress pathological immune responses in the setting of
transplantation, allergy, or autoimmune disease. Their suppressive capacity is not always beneficial, since they can also suppress immune response to antigens of tumors or pathogens (12). *H. pylori*-specific regulatory T cells were previously described as suppressing the memory T-cell response to *H. pylori* in infected individuals (31). This suppression may contribute to the inability of the immune system to clear this bacterial infection. Pathogens which interact with DC-SIGN, the human immunodeficiency virus type 1 receptor on DCs, cause chronic infections and are reported to enhance IL-10 production (40). Binding of DC-SIGN to Le^X^-positive *H. pylori* lysate was recently demonstrated (3). Other studies suggest that IL-10 production is TLR4 mediated (15). These results are of particular interest since there is evidence that *H. pylori* activation is mediated by TLR2 and TLR5 but not by TLR4 (51). The receptor-organism interaction that results in IL-10 release needs further investigation. Whether the IL-10 production triggers the immune escape mechanisms of *H. pylori* by generating Tr-1 cells or whether the moderate IL-10 release in presence of huge amounts of IL-12 is not sufficient to generate a beneficial Th2 response is yet unclear and remains to be analyzed in more detail.

We have shown that *H. pylori* is a maturation stimulus for human monocyte-derived DCs. Incubation of DCs for 72 h with *H. pylori* or LPS generated phenotypically mature DCs with high levels of expression of costimulatory molecules (CD80, CD83, and CD86) and of MHC class II. Thus far, these results suggest no inhibitory potential of *H. pylori* on the innate immune system which would eventually explain one of the

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**TABLE 2.** *H. pylori* induces upregulation of surface molecules on DCs independently of the serostatus

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CD80</th>
<th>CD83</th>
<th>CD86</th>
<th>HLA-DR</th>
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<tr>
<td>PBS</td>
<td>3.2</td>
<td>5.1</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>LPS</td>
<td>53.1</td>
<td>23.0</td>
<td>7.3</td>
<td>3.0</td>
</tr>
<tr>
<td><em>H. pylori</em></td>
<td>20.3</td>
<td>9.3</td>
<td>4.6</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*Immature DCs were incubated with PBS, *H. pylori* (MOI = 10), or LPS (100 ng/ml) for 72 h. The MFI values for different surface molecules are shown from two representative experiments (n = 7).
immune escape mechanisms of this persistent pathogen. Thus, further studies are required to investigate the biologic activity of *H. pylori*-induced mature DCs in the context of DC–T-cell interaction. Immature DCs are very efficient in antigen capture. They use different pathways to internalize antigens: phagocytosis (17, 33), macropinocytosis (48), and adsorptive endocytosis (19, 55). Previous studies on monocytes described the inhibition of phagocytosis by *H. pylori* involving CagA secretion components (44). It would be of great interest to investigate the antiphagocytic activity on immature DCs. Further investigation is needed to elucidate the interaction between DC and *H. pylori* in detail and to investigate the activation cascade downstream of cell surface receptors.

**ACKNOWLEDGMENTS**

We thank Marina Kreutz (Department Hematology, University Hospital Regensburg) for providing the flow cytometry profile of immature dendritic cells and Jörg Marienhagen for reviewing the statistical analysis.

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