Polymorphisms of TLR9 gene are associated with a decreased risk of H. pylori infection in a Chinese population

Fang Gao¹#, Jindong Qin²#, Xingru Wei¹, Xuyang Tian⁴, Wenjie Dong³, Tong Dang⁴, Yanbin Jia³,4*

¹School of Medical Technology, ²Department of Sports Rehabilitation, ³School of Basic Medicine and Forensic Medicine, Baotou Medical College, Baotou 014060, China; ⁴Inner Mongolia Institute of Digestive Diseases, the Second Affiliated Hospital of Baotou Medical College, Baotou 014030, China

Contributions: (I) Conception and design: F Gao, J Qin, T Dang, Y Jia; (II) Administrative support: None; (III) Provision of study materials or patients: F Gao, X Tian, T Dang, Y Jia; (IV) Collection and assembly of data: F Gao, J Qin, X Wei, X Tian; (V) Data analysis and interpretation: F Gao, J Qin, W Dong, Y Jia; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

#These authors contributed equally to this work.

*Correspondence to: Yanbin Jia. School of Basic Medicine and Forensic Medicine, Baotou Medical College, 31 Jianshe Road, Donghe District, Baotou 014060, China. Email: jyb690318@hotmail.com; Tong Dang. Inner Mongolia Institute of Digestive Diseases, The Second Affiliated Hospital of Baotou Medical College, 30 Hudumen Street, Qingshan District, Baotou 014030, China. Email: dtong999@sina.com.

Background: A series of evidence suggests that genetic variation in toll-like receptor (TLR) 9 might influence the outcome of Helicobacter pylori (H. pylori) infection and play an important role in gastric carcinogenesis.

Methods: We conducted a case-control study to evaluate TLR9 polymorphisms on the risk of H. pylori infection and non-cardia gastric cancer (GC) in a Chinese population. We genotyped a tagging single-nucleotide polymorphism (SNP), rs164640, and a potentially functional SNP, rs187084, by TaqMan technique among 288 patients with non-cardia GC and 281 controls. Unconditional logistic regression (LR) was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for SNPs in association with H. pylori infection and non-cardia GC risk.

Results: Our results indicated that among normal controls, the minor allele homozygotes of both SNPs were significantly associated with a decreased risk of H. pylori infection when compared with their major allele homozygotes (for rs164640: OR =0.41, 95% CI, 0.18–0.93; for 187084: OR =0.38, 95% CI, 0.17–0.85). However, neither of the two SNPs demonstrated a significant association with non-cardia GC risk.

Conclusions: Our results revealed that TLR9 polymorphisms might have effects on the risk of H. pylori infection, but they do not seem to contribute to the risk of non-cardia GC in our studied population.

Keywords: Helicobacter pylori (H. pylori); non-cardia gastric cancer (GC); single nucleotide polymorphism; toll-like receptor 9 (TLR-9)

Submitted Jun 22, 2019. Accepted for publication Oct 10, 2019.
doi: 10.21037/tcr.2019.11.45
View this article at: http://dx.doi.org/10.21037/tcr.2019.11.45

Introduction

Gastric cancer (GC) is a serious public health burden as the third leading cause of cancer death worldwide (1). Like many malignancies, it is accepted that gastric oncogenesis is a complex multifactorial process resulting from host genetics, lifestyle, and environmental factors (2). Epidemiological studies suggest that Helicobacter pylori (H. pylori) infection is the main cause of non-cardia GC, and

*The present address of Yanbin Jia: The Nursing School of Baotou Medical College, Baotou 014060, China.
*H. pylori* have been identified as a class I carcinogen (3,4). The cases with *H. pylori* infection have an increased 3–20 fold or even higher risk of developing non-cardia GC (5,6). As genetic polymorphisms are related to the diversity and inter-individual variation, they have been recently recognized as the major genetic elements influencing the GC risk.

*H. pylori* infection can initiate an inflammatory response through its components, which include lipopolysaccharides, DNA, etc., and these components are sensed by transmembrane Toll-like receptors (TLRs) (7). TLRs are critical innate immunity regulators and can be activated by pathogen-associated molecular patterns (PAMPs), which are shared by lots of microorganisms (8). In the human stomach, gastric epithelial cells express TLR2, TLR4, TLR5, and TLR9 (9), play a key role in the host’s innate immunity against *H. pylori* (10,11). In particular, TLR9 identifies unmethylated CpG oligonucleotides in bacterial DNA (9). Many studies have shown the role of TLR9 in *H. pylori* infection and GC; thus, compared with the noninfamed gastric mucosa, TLR9 expression tends to be higher in the gastric epithelium in *H. pylori*-related gastritis, and TLR9 polarization seems to be a process dynamically influenced by *H. pylori* (12). TLR9 signaling pathway has anti-inflammatory effects on the early stages of *H. pylori*-related gastritis (13). *H. pylori* DNA can induce TLR9-mediated GC cell invasion (14). Also, TLR9 is aberrantly expressed in GC (15), and TLR9 promoter polymorphism is correlated with both an increased risk of GC and poor prognosis (16).

Given that the TLR9 signaling pathway plays an important role in *H. pylori* infection and GC development, and dysregulation of the TLR9 signaling owing to a single-nucleotide polymorphism (SNP) may alter the ligand binding, we performed a case-control study to investigate the associations of TLR9 genetic variations with *H. pylori* infection and GC risk, using tag-SNP and selected candidate functional SNPs in a Han Chinese population. Because non-cardia gastric and cardia GCs are different in their etiology, pathology, oncogenesis, and prognosis (17), and *H. pylori* infection is more related to an increased risk of non-cardia GC (5), we limited our cases to non-cardia GC patients in order to have a relatively more homogeneous subject group and enhance the association study power.

## Methods

### Subjects

We recruited 288 cases at the Cancer Hospital of Baotou between June 2008 and December 2010, as described previously (18,19). All patients were histopathologically diagnosed as incident non-cardia GC. The patients who had secondary cancer, recurrent cancer, radiotherapy, or chemotherapy were excluded. Meanwhile, 281 cancer-free individuals with no identifiable gastric disease or autoimmune disease were randomly collected as controls from a community health examination program. The controls were frequency-matched to the cases for age (±5 years) and sex. All subjects were unrelated ethnic Han Chinese residents in Baotou, Inner Mongolian Autonomous Region, northwest China. At recruitment, each subject was personally interviewed to gather demographic data and lifestyle factors such as smoking and alcohol consumption. Individuals who formerly or currently smoked ≥1 cigarette per day for more than one year were defined as smokers. Subjects that drunk at least twice a week for more than one year were defined as drinkers. No significant differences were found in age, gender, or drinking status between the two groups. There were more smokers in cancer cases than in controls (P=0.03). This study was approved by the institutional review board of Baotou Medical College, and informed consent was obtained from each subject.

### Tests for *H. pylori* infection

*H. pylori* status was serologically analyzed in controls. Anti-*H. pylori* serum IgG antibody was determined using a commercial enzyme-linked immunosorbent assay (ELISA) kits (Biohit, Helsinki, Finland). According to the manufacturer’s recommendation, an anti-*H. pylori* IgG titer ≥30 EIU was defined as positive for *H. pylori* infection.

### SNP Selection and genotyping

Using HapMap Phase 2 data of the Han Chinese population (http://hapmap.ncbi.nlm.nih.gov), SNP rs164640 was selected as a tagSNP by Tagger algorithm as implemented in Haploview. The screen area included the whole gene, 20 kb upstream of the first exon, and 10 kb downstream of
the termination of the last exon. Parameters of \( r^2 > 0.8 \) and a minor allele frequency (MAF) \( \geq 0.05 \) in the Han Chinese population were used for selection. Besides, SNP rs187084 was reported to be associated with an increased risk of GC in a Chinese population (16), so we also analyzed this SNP in the present study.

Genomic DNA was isolated from peripheral blood using proteinase K digestion, followed by phenol-chloroform purification and ethanol precipitation. Both SNPs were genotyped by the TaqMan allelic discrimination using ABI assay-by-designs (Applied Biosystems, Foster City, CA, USA); the genotyping was finished at the Chinese National Human Genome Center, Beijing. For the two SNPs, the success rate of genotyping was higher than 97.9%. In order to achieve the purpose of quality control, about 5% of the samples with high-quality DNA were randomly selected and genotyped twice. The results were 100% consistent.

**Statistical analysis**

All statistical analyses were performed by SPSS software version 16.0 (SPSS Inc., Chicago, IL, USA). Patients and controls were compared by Student's \( t \)-test for age and chi-square test (\( \chi^2 \)) for gender, smoking, and drinking status. Hardy-Weinberg equilibrium (HWE) was measured by a goodness-of-fit \( \chi^2 \) test. The Haplotype frequencies were inferred by Haplovie 4.0 program. Unconditional logistic regression (LR) was used to estimate the \( H. pylori \) infection and non-cardia GC risk in association with tested SNPs.

**Results**

The selected characteristics of the 288 cases with non-cardia GC and 281 normal controls are described in Table 1. The genotype frequencies of both SNPs followed HWE in controls.

In controls, both SNPs showed statistically significant associations with \( H. pylori \) infection (Table 2). Minor allele homozygotes of both SNPs were significantly associated with a decreased risk of \( H. pylori \) infection when compared with their major allele homozygotes, with adjusted OR = 0.41, 95% CI, 0.18–0.93 for rs164640 AA genotype, and adjusted OR =0.38, 95% CI, 0.17–0.85 for rs187084 GG genotype respectively. However, no significant association between any haplotypes and \( H. pylori \) infection risk was observed (Table 3).

Neither of the two SNPs analyzed demonstrated a

---

**Table 1** Selected characteristics of study subjects

| Variable     | Controls, n (%) | Cases, n (%) | P value |
|--------------|-----------------|--------------|---------|
| Overall      | 281 [100]       | 288 [100]    |         |
| Gender       |                 |              |         |
| Male         | 220 (78.3)      | 224 (77.8)   | 0.88    |
| Female       | 61 (21.7)       | 64 (22.2)    |         |
| Age (year)   |                 |              |         |
| Mean ± SD    | 59.10±11.57     | 59.48±11.23  | 0.69    |
| Range        | 26–85           | 26–83        |         |
| Smoking status|                |              |         |
| No           | 180 (64.1)      | 159 (55.2)   | 0.03    |
| Yes          | 101 (35.9)      | 129 (44.8)   |         |
| Drinking status|             |              |         |
| No           | 145 (51.6)      | 143 (49.7)   | 0.64    |
| Yes          | 136 (48.4)      | 145 (50.3)   |         |

**Table 2** Association between tested SNPs and \( H. pylori \) infection in controls

| SNPs         | Genotypes | \( H. pylori \) (+), n (%)a | \( H. pylori \) (−), n (%)a | OR (95% CI)b | P value |
|--------------|-----------|-----------------------------|-----------------------------|--------------|---------|
| rs164640     | GG        | 39 (32.8)                   | 54 (34.8)                   | 1            |         |
|              | AG        | 70 (58.8)                   | 68 (43.9)                   | 1.40 (0.82–2.39) | 0.21    |
|              | AA        | 10 (8.4)                    | 33 (21.3)                   | 0.41 (0.18–0.93) | 0.03    |
| rs187084     | TT        | 41 (33.9)                   | 52 (34.4)                   | 1            |         |
|              | TC        | 70 (57.9)                   | 66 (43.7)                   | 1.34 (0.79–2.27) | 0.29    |
|              | CC        | 10 (8.3)                    | 33 (21.9)                   | 0.38 (0.17–0.85) | 0.02    |

a, sum of column did not add up to total study subjects because of missing data; b, adjusted for age and sex. SNP, single-nucleotide polymorphism.
significant association with the risk of non-cardia GC either by single SNP analysis or by haplotype analysis (Tables 4, 5).

Furthermore, the additional models, adjusted for other factors, including smoking and drinking status, gave qualitatively similar results for the association between *H. pylori* infection or non-cardia GC and the tested SNPs (data not shown).

**Discussion**

In light of the extensive epidemiological evidence, *H. pylori* is an important risk factor for non-cardia GC development (3,4). Previous studies have shown that TLR9 is responsible for initiating innate immune responses to *H. pylori* CpG DNA (13), while TLR9 expression has been shown to be altered upon the *H. pylori* infection and GC (12,15).

Because genetic variation, particularly in the polymorphic sites of the TLR9 gene, may change the transcription and expression process and potentially influence the outcome of *H. pylori* infection, we performed a case-control study to evaluate the associations of TLR9 polymorphisms with susceptibility to *H. pylori* infection and non-cardia GC risk. Our results revealed that TLR9 SNP rs164640 and rs187084 were associated with a decreased risk of *H. pylori* infection, but not associated with non-cardia GC risk, suggesting that common genetic variations in the TLR9 gene only play an important role at the early stage of the gastric carcinogenesis. Interestingly, some studies reported that TLR9 expression was upregulated in *H. pylori*-induced gastritis (12), but was not detectable in intestinal metaplasia or dysplasia, the important precursor lesions of GC, and only focally detectable in limited gastric tumor cells (15). Furthermore, variants in other genes that play a key role in *H. pylori*-related GC have also been recognized as risk factors in the precursor stages of the disease process but not at the cancer stage (20). The evidence mentioned above

---

**Table 3** Associations between haplotypes and *H. pylori* infection

| Haplotypes | *H. pylori (+) (%)| *H. pylori (-) (%) | OR (95% CI) | P value |
|------------|------------------|-------------------|-------------|---------|
| GT         | 62.1             | 55.7              | 1           |         |
| AC         | 36.9             | 42.8              | 0.77 (0.54–1.08) | 0.14    |
| GC         | 0.5              | 0.9               | 0.41 (0.04–4.04) | 0.42    |
| AT         | 0.5              | 0.6               | 1.12 (0.16–8.08) | 0.87    |

* a, the SNP order was rs164640, rs187084; b, adjusted for age and sex.

**Table 4** Association between tested SNPs and non-cardia gastric cancer

| SNPs      | Genotype | Controls, n (%) | Cases, n (%) | OR (95% CI) | P value |
|-----------|----------|-----------------|--------------|-------------|---------|
| rs164640  | GG       | 93 (33.9)       | 95 (33.7)    | 1           |         |
|           | AG       | 138 (50.4)      | 134 (47.5)   | 0.95 (0.65–1.38) | 0.78    |
|           | AA       | 43 (15.7)       | 53 (18.8)    | 1.21 (0.74–1.99) | 0.45    |
| rs187084  | TT       | 93 (34.2)       | 96 (33.6)    | 1           |         |
|           | TC       | 136 (50.0)      | 134 (46.9)   | 0.95 (0.65–1.38) | 0.78    |
|           | CC       | 43 (15.8)       | 56 (19.6)    | 1.26 (0.77–2.05) | 0.37    |

* a, sum of column did not add up to total study subjects because of missing data; b, adjusted for age and sex.

**Table 5** Associations between haplotypes and risk of non-cardia gastric cancer

| Haplotypes | Cases (%) | Controls (%) | OR (95% CI) | P value |
|------------|-----------|--------------|-------------|---------|
| GT         | 55.7      | 58.3         | 1           |         |
| AC         | 41.5      | 40.3         | 1.08 (0.85–1.37) | 0.52    |
| GC         | 1.4       | 0.7          | 2.02 (0.60–6.77) | 0.25    |
| AT         | 1.4       | 0.7          | 2.08 (0.62–6.98) | 0.25    |

* a, the SNP order was rs164640, rs187084; b, adjusted for age and sex.
indicates that our results might not be random.

It is generally accepted that host genetic factors could influence the susceptibility to *H. pylori* infection. Previous studies have shown that about 5% to 10% of a population remain uninfected with *H. pylori* under a higher exposure condition (21). A significantly higher concordance for *H. pylori* infection was found in monozygotic than in dizygotic twins, while host genetic variation could contribute 57% of the variation in acquiring *H. pylori* infection (22). The heterozygous variant of TLR9 rs352140 favors the persistence of the *H. pylori* infection (23). Recently, a few studies have focused on SNP rs5743836 in the TLR9 gene. One study has shown that rs5743836 is not associated with *H. pylori* infection in Caucasians (11). However, the minor allele of rs5743836 is very rare in the Chinese population (16). Because tagSNPs, which represent SNPs in a region of the genome with high linkage disequilibrium (LD), can identify genetic variations without genotyping every SNP in a chromosomal region, we genotyped tagSNP rs164640 as a surrogate to estimate the association between TLR9 genetic variation and *H. pylori* infection in the present study, and found this SNP was associated with a decreased risk of *H. pylori* infection. The discrepancy between the two studies may be due to racial differences and a difference in the selection of study subjects. In our study, we analyzed the relationship between SNP and *H. pylori* infection only in normal controls with no identifiable gastric disease, but in Ng’s study, the analyzed subjects including all infected patients with or without precancerous abnormalities. In addition, in silico analysis has shown that TLR9 promoter SNP rs187084 creates a putative Sp1 binding site, which may be functionally relevant (24). Thus, we also analyzed this SNP in the present study and found it was also associated with the susceptibility to *H. pylori* infection. Based on our data, rs164640 and rs187084 were in high LD with D’=0.954 and r²=0.911. SNP rs187084 may be the real causal variant in *H. pylori* infection. The precise mechanism of both tested SNPs in the risk of *H. pylori* infection has to be elucidated in further studies.

Currently, a very limited number of studies have analyzed the association between TLR9 polymorphisms and GC risk. For example, Hold et al. (25) reported that TLR9 rs5743836 was not associated with GC in Caucasian populations. Trejo-de la et al. (26) found that rs5843836 and rs352140 in the TLR9 gene were not associated with GC in a Mexican population. Another two studies suggested that rs187480 was not associated with the risk of GC in a northern Chinese population (27,28). However, Wang’s study showed that rs187084 was associated with increased susceptibility to non-cardia GC, but was not associated with *H. pylori* infection in controls among an eastern Chinese population (16), which is inconsistent with our study. The reason for the discrepancy is unclear, but it could be attributable to other environmental risk factors or the heterogeneous genetic backgrounds between different subpopulations.

Some limitations of our study need to be addressed. First, we did not obtain information on *H. pylori* infection in some cases, which restricted us to adjust this potential confounding bias in the analysis. However, it is difficult to estimate *H. pylori* infection in GC patients because the loss of *H. pylori* from the stomach and decreased immune response always occurs during gastric tumorigenesis (29). Furthermore, patients could have possibly received long-term *H. pylori* eradication therapy, and significant serological changes would probably have occurred over the therapy process. Second, our sample size was relatively small, so our results were only considered to be exploratory screening in nature.

In conclusion, this preliminary study suggests that SNP rs164640 and rs187084 in the TLR9 gene are not associated with non-cardia GC risk, but our findings offer the first evidence of the association between polymorphisms of the TLR9 gene and a decreased risk for *H. pylori* infection in a Chinese population. Functional and future large-scale studies are needed to elucidate the role of genetic variations in the TLR9 gene in the carcinogenesis of non-cardia GC.

**Acknowledgments**

**Funding:** This study is supported by the National Natural Science Foundation of China (No. 81250024, 81650017); the Natural Science Foundation of Inner Mongolia (2016MS0805); the Scientific Research Fund of Baotou Medical College (BYJJ-DF 201603).

**Footnote**

**Conflicts of Interest:** The authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/tcr.2019.11.45). The authors have no conflicts of interest to declare.

**Ethical Statement:** The authors are accountable for all aspects of the work in ensuring that questions related
to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of Baotou Medical College (No. 2012003). Informed consent was obtained from each subject.

Open Access Statement: This is an Open Access article distributed in accordance with the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License (CC BY-NC-ND 4.0), which permits the non-commercial replication and distribution of the article with the strict proviso that no changes or edits are made and the original work is properly cited (including links to both the formal publication through the relevant DOI and the license). See: https://creativecommons.org/licenses/by-nc-nd/4.0/.

References

1. Ferlay J, Soerjomataram I, Dikshit R, et al. Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN2012. Int J Cancer 2015;136:E359-86.
2. Correa P. Gastric cancer: overview. Gastroenterol Clin North Am 2013;42:211-7.
3. Peek RM Jr, Blaser MJ. Helicobacter pylori and gastrointestinal tract adenocarcinomas. Nat Rev Cancer 2002;2:28-37.
4. Polk DB, Peek RM Jr. Helicobacter pylori: gastric cancer and beyond. Nat Rev Cancer 2010;10:403-14.
5. Kamangar F, Dawsey SM, Blaser MJ, et al. Opposing risks of gastric cardia and noncardia gastric adenocarcinomas associated with Helicobacter pylori seropositivity. J Natl Cancer Inst 2006;98:1445-52.
6. Malfertheiner P, Megraud F, O’Morain CA, et al. Management of Helicobacter pylori infection--the Maastricht IV/ Florence Consensus Report. Gut 2012;61:646-64.
7. Uno K, Kato K, Shimosegawa T. Novel role of toll-like receptors in Helicobacter pylori - induced gastric malignancy. World J Gastroenterol 2014;20:5244-51.
8. Szatmary Z. Molecular biology of toll-like receptors. Gen Physiol Biophys 2012;31:357-66.
9. Kumar H, Kawai T, Akira S. Pathogen recognition by the innate immune system. Int Rev Immunol 2011;30:16-34.
10. Kawahara T, Kuwano Y, Teshima-Kondo S, et al. Toll-like receptor 4 regulates gastric pit cell responses to Helicobacter pylori infection. J Med Invest 2001;48:190-7.
11. Ng MT, Van’t Hof R, Crockett JC, et al. Increase in NF-κappaB binding affinity of the variant C allele of the toll-like receptor 9 -1237T/C polymorphism is associated with Helicobacter pylori-induced gastric disease. Infect Immun 2010;78:1345-52.
12. Schmausser B, Andrusi M, Endrich S, et al. Expression and subcellular distribution of toll-like receptors TLR4, TLR5 and TLR9 on the gastric epithelium in Helicobacter pylori infection. Clin Exp Immunol 2004;136:521-6.
13. Otani K, Tanigawa T, Watanabe T, et al. Toll-like receptor 9 signaling has anti-inflammatory effects on the early phase of Helicobacter pylori-induced gastritis. Biochem Biophys Res Commun 2012;426:342-9.
14. Kauppila JH, Karttunen TJ, Saarnio J, et al. Short DNA sequences and bacterial DNA induce esophageal, gastric, and colorectal cancer cell invasion. APMIS 2013;121:511-22.
15. Schmausser B, Andrusi M, Endrich S, et al. Toll-like receptors TLR4, TLR5 and TLR9 on gastric carcinoma cells: an implication for interaction with Helicobacter pylori. Int J Med Microbiol 2005;295:179-85.
16. Wang X, Xue L, Yang Y, et al. TLR9 promoter polymorphism is associated with both an increased susceptibility to gastric carcinoma and poor prognosis. PLoS One 2013;8:e65731.
17. Shi Y, Hu Z, Wu C, et al. A genome-wide association study identifies new susceptibility loci for non-cardia gastric cancer at 3q13.31 and 5p13.1. Nat Genet 2011;43:1215-8.
18. Zhang B, Hao GY, Gao F, et al. Lack of association of common polymorphisms in MUC1 gene with H. pylori infection and non-cardia gastric cancer risk in a Chinese population. Asian Pac J Cancer Prev 2013;14:7355-8.
19. Zhou CJ, Zhang LW, Gao F, et al. Association analysis of common genetic variations in MUC5AC gene with the risk of non-cardia gastric cancer in a Chinese population. Asian Pac J Cancer Prev 2014;15:4207-10.
20. Savage SA, Hou L, Lissowska J, et al. Interleukin-8 polymorphisms are not associated with gastric cancer risk in a Polish population. Cancer Epidemiol Biomarkers Prev 2006;15:589-91.
21. Bardhan PK. Epidemiological features of Helicobacter pylori infection in developing countries. Clin Infect Dis 1997;25:973-8.
22. Malaty HM, Engstrand L, Pedersen NL, et al. Helicobacter pylori infection: genetic and environmental
influences. A study of twins. Ann Intern Med 1994;120:982-6.

23. Loganathan R, Nazeer M, Goda V, et al. Genetic variants of TLR4 and TLR9 are risk factors for chronic Helicobacter pylori infection in South Indian Tamils. Hum Immunol 2017;78:216-20.

24. Hamann L, Glaeser C, Hamprecht A, et al. Toll-like receptor (TLR)-9 promoter polymorphisms and atherosclerosis. Clin Chim Acta 2006;364:303-7.

25. Hold GL, Rabkin CS, Gammon MD, et al. CD14-159C/T and TLR9-1237T/C polymorphisms are not associated with gastric cancer risk in Caucasian populations. Eur J Cancer Prev 2009;18:117-9.

26. Trejo-de la O A, Torres J, Sánchez-Zauco N, et al. Polymorphisms in TLR9 but not in TLR5 increase the risk for duodenal ulcer and alter cytokine expression in the gastric mucosa. Innate Immun 2015;21:706-13.

27. Liu S, Wang X, Shi Y, et al. Toll-like receptor gene polymorphisms and susceptibility to Epstein-Barr virus-associated and -negative gastric carcinoma in Northern China. Saudi J Gastroenterol 2015;21:95-103.

28. Zeng HM, Pan KF, Zhang Y, et al. The correlation between polymorphisms of Toll-like receptor 2 and Toll-like receptor 9 and susceptibility to gastric cancer. Zhonghua Yu Fang Yi Xue Za Zhi 2011;45:588-92.

29. Farinati F, Valiante F, Germanà B, et al. Prevalence of Helicobacter pylori infection in patients with precancerous changes and gastric cancer. Eur J Cancer Prev 1993;2:321-6.

Cite this article as: Gao F, Qin J, Wei X, Tian X, Dong W, Dang T, Jia Y. Polymorphisms of TLR9 gene are associated with a decreased risk of H. pylori infection in a Chinese population. Transl Cancer Res 2020;9(2):683-689. doi: 10.21037/tcr.2019.11.45