MGMT Gene rs1625649 Polymorphism in Iranian Patients with Brain Glioblastoma: A Case Control Study

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Abstract

Glioblastoma (GBM) is the most common and aggressive primary malignant brain tumor with poor prognosis and high potential of dispersion to other brain tissues in adult. Effective and modern choices of treatment including chemotherapy with alkylating agents marginally extend survival of GBM. However, alkylating agents can lead to highly harmful mismatch during DNA replication causing apoptosis and cell death. Accordingly, O6-Methylguanine-DNA methyltransferase (MGMT) removes alkyl adducts, thereby causing resistance to alkylating drugs. Single-Nucleotide Polymorphisms (SNPs) in MGMT promoter region may play a role in the regulation of MGMT expression and prediction of glioma development risk. In order to evaluate the clinical significance of rs1625649 SNP in the MGMT promoter region of glioblastoma, genomic DNA from a series of 54 patients with GBM and 50 healthy individuals in Iranian population were collected for tetra ARMS PCR amplification. None of the ”A” or ”C” alleles were associated with tumor occurrence, the ”AA” genotype was more frequent in healthy subjects, and the ”AC” genotype was 4.6 times more common in patients with GBM. The longest survival time was observed in the ”CC” genotype; however, this difference was not statistically significant. On the other hand, homozygous rs1625649 (AA genotype) was significantly associated with a better survival than the cases with heterozygous rs1625649 (CA genotype) or wild type rs1625649 (CC genotype), predicting better response to temozolomide-based chemotherapy.

Keywords: GBM, Glioblastoma multiforme, MGMT, O6-Methylguanine DNA methyltransferase, SNP

tomas have a higher prevalence in men and in white people despite their lower incidence in Asians. The median overall survival for patients diagnosed with GBM is 12-15 months and only 5% of the patients may survive for 5 years after the diagnosis. While most GBMs are primary tumors (WHO astrocytoma grade IV), highly invasive, and more commonly occur in older patients, secondary GBMs (grade II) are much less common, associated with more favorable prognostic outcomes, and often occur in younger patients compared to primary ones. In other words, although primary and secondary GBMs are histologically indistinguishable, they develop from different origins, and are associated with distinct genetic abnormalities caused by molecular alterations. Modern choices of treatment for glioblastoma include surgical resection followed by radiation therapy or combined radiation and chemotherapy with alkylating agents such as Temozolomide (TMZ). These conventional therapies marginally increase the average rate of survival, however, despite all the treatment modalities most GBM patients die within 2 years of initial diagnosis.

Alkylating agents can lead to highly harmful mismatch in O6-methylguanine DNA (O6-MeG) during DNA replication causing apoptosis and cell death. O6-Methylguanine DNA methyltransferase (MGMT), as a DNA repair protein, removes alkyl adducts, prevents the formation of cross-links and G\&A mutations in the genome, thereby causing resistance to alkylating drugs. Epigenetic silencing by aberrant promoter methylation of MGMT, located at chromosome 10q26, is a clinical predictor to overall survival, since it leads to inefficient repair of DNA alkylation and enhanced response to alkylating agents in GBM. Both Cytosine phosphate-Guanine (CpG) methylation and Single-Nucleotide Polymorphisms (SNPs) in the MGMT promoter/enhancer region have been found to play important roles in the regulation of MGMT transcription and its downstream protein expression, which can be associated with risk of developing glioma. In other words, polymorphisms in the MGMT gene may affect the primary structure, expression and DNA repair activity of MGMT.

The purpose of this study was to investigate the association of MGMT SNP (rs1625649) in the gene promoter region with GBM and evaluate the clinical relevance of the respective genotypes in Iranian patients with GBMs.

Materials and Methods

Study population
A series of 54 patients with GBM and 50 healthy individuals with no history of any kind of tumors as control group were selected from Arad and Imam Hossein Hospitals, Tehran, Iran, from 2018 to 2020. The inclusion criteria included patients with newly diagnosed glioblastoma who underwent surgery based on clinical signs (seizures, severe headaches, speech difficulty, and vision disturbance), Magnetic Resonance Imaging (MRI) and histological diagnosis, whereas the samples of control group were obtained from autopsies of healthy subjects.

The most suitable cross section of brain specimens by visual microscopic assessment (>70% neoplastic cells and <50% necrosis) were fixed by Formalin-Fixed Paraffin Embedded (FFPE) protocol. Medical records of all patients were reviewed and follow-up data were collected by accessing patients’ files, and contacting the patients whenever necessary. Basic clinical and demographic data were collected including age, gender, surgical procedure, treatment and overall survival. All investigations described in the current case-control study was approved by the Ethical Committee of Tehran University of Medical Sciences, Tehran, Iran.

DNA extraction
The DNA was isolated from FFPE brain samples by the use of the Phenol: Chloroform Method to extract the amount of DNA required for genotyping, and the purity and yield of DNA were assessed by using a NanoDrop spectrophotometer. Firstly, tissue cores or microdissected tissue were deparaffinized by two-step xylene treatment, which dissolves the paraffin from the tissue, followed by rehydration using a series of descending concentrations with ethanol washes (96, 75, and 50%). Then, all pellets were digested by 20 µl proteinase K (20 mg/ml) (Merck, Germany) and 500 µl lysis buffer [1 M Tris-HCl (pH=8.2), 0.5 M Na2-EDTA, and 100 µl 10% Sodium Dodecyl Sulfate (SDS) (Merck, Germany)]. After overnight incubation at 55°C in a heating block, the mixture of the supernatant with an equal volume of phenol (Merck, Germany) was centrifuged at 12000xg and 4°C for 5 min. Next, the equal volume of phenol/chloroform/isoamyl alcohol mixture (25:24:1) was added to the transformed aqueous layer to separate the proteins from the DNA and then centrifuged for 5 min at 12000xg to separate double-stranded DNA molecules in the aqueous phase from the unwanted proteins and cellular debris. DNA was precipitated by adding 0.1 unit of 3 M sodium acetate (Merck, Germany) and 1 unit of chilled isopropanol (Merck, Germany) and incubation at -20°C for 60 min. After centrifuge for 10 min at 12000xg at 4°C, the dried pellet was washed with 1 ml chilled alcohol 70% twice, to remove contaminations. The DNA was re-suspended in 50 µl of distilled water and stored in the -20°C freezer for further molecular analysis.

Tetra primer amplification refractory mutation system polymerase chain reaction (ARMS PCR)
SNP has more applications due to its higher frequency compared with other genetic variations. Tetra primer ARMS PCR is a fast detection method with more simplicity at a negligible cost for SNP genotyping which consists of two sets of primers; the outer and inner primers. The outer primers amplify DNA se-

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The majority of patients had family history of either brain tumor or other cancers (Table 2).

Association of rs1625649 with GBM

Allele and genotype distribution of rs1625649 (C485A) were assessed in the patients and control subjects. The A and C alleles were similarly distributed in patients and controls, with no significant difference (p>0.05). On the other hand, while the AA genotype was significantly more frequent in healthy subjects (p=0.009), the AC genotype was 4.6 times more frequent in GBM patients (p<0.0005) (Table 3).

Association of rs1625649 with tumor location

In this case tumor location was not influenced by either of rs1625649 genotypes (p=0.9) (Table 4).

Association of rs1625649 genotype and patients' survival

The mean overall survival was slightly different between three genotypes of rs1625649, with the longest survival time in CC genotype. However, this difference...
Discussion

The MGMT gene is responsible for encoding a protein with main function of alkyl group removal from O\(^6\) position of guanine. Any dysfunction of mis-structure of MGMT may result in accumulation of abnormal MGMT protein in cancer cells, which leads to inefficient activity of alkylating chemotherapeutic agents 16. The SNP of MGMT could possibly alter the gene and/or protein structure leading to protein malfunction. Importantly, as there could be a heterogeneity in MGMT function in different parts of a tumor in one patient, it could explain the unfavorable responses to treatment despite low levels of MGMT expression 17. The current case-control study was designed to determine the association of MGMT SNP (rs1625649) with GBM in a series of Iranian patients. As explained in detail, while none of the "A" or "C" alleles were associated with tumor occurrence, the "AC" genotype was more frequent in healthy subjects (OR=0.28, p=0.009), and the "CC" genotype was 4.6 times more common in patients with GBM (p=0.0005).

The rs1625649 is located on promotor region of the gene 17, and so far, its association with different cancers was assessed. In a series of 118 patients with GBM, rs1625649 was found in 37% of patients with the "AA" genotype being associated with more favorable progression free survival and lower MGMT protein levels in patients with MGMT-methylated GBM 18. Considering cancers, this SNP was not significantly associated with squamous cell carcinoma of larynx in Chinese population 10. Moreover, it was proposed that some haplotypes of MGMT may influence the sensitivity to alkylating agents more than the SNPs alone 19. It is also reported that rs1625649 was associated with allelic expression imbalance and downregulation of the MGMT promoter activity 20.

Conclusion

Despite the attempts to prevent biases in the current study, the sample size was not large enough to general-
ize the results to the whole population of GBM patients. Moreover, and as most of genetic factors are influenced by the environment as well as other genetic variants, the association of SNPs should be evaluated in MGMT-methylated vs. MGMT unmethylated GBM patients, together with other SNPs. Co-evaluation of serum vs. tumoral levels of proteins could be valuable to determine whether a SNP had effects on protein expression.

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Conflicts of Interest
The authors declare no conflict of interest.

References