



# Galactomannan Antigen Detection as a Screening Tool For Early Diagnosis of Invasive Aspergillosis: Experience of Turkish Adult Patients

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INVITED  
REVIEW

ABSTRACT

**Objective:** The aim of the present study was to investigate the usefulness of galactomannan (GM) antigen as a screening test for the early diagnosis of invasive aspergillosis (IA) in adult patients in Turkish centers.

**Materials and Methods:** PubMed was searched using the keywords “galactomannan” and “Turkey.” Only studies that used the GM antigen as a screening tool in adult patients were included in the analysis.

**Results:** Four peer-reviewed articles that matched the inclusion criteria were identified. A total of 314 adult patients with several hematological malignancies and who underwent allogeneic hematopoietic stem cell transplantation were included in the four studies. Patients were followed up for 459 neutropenia episodes. GM antigen testing was performed in 2662 serum samples. The sensitivity, specificity, positive predictive value, and negative predictive value were 23.07%–100%, 5.7%–90.36%, 6.7%–73.07%, and 55.5%–100%, respectively. Early diagnosis of IA by GM screening was found in only one patient in one of the four studies.

**Conclusion:** The performance of the GM antigen test as a screening tool in Turkish centers was not promising. However, it can be used as a diagnostic test for patients with clinical and radiological findings suggesting invasive fungal disease.

**Keywords:** Galactomannan, invasive aspergillosis, diagnosis, Turkey

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## INTRODUCTION

The diagnosis of invasive aspergillosis (IA) is a challenge in patients with hematological malignancies. Although isolation of *Aspergillus* species from fungal culture is the gold standard, several conditions such as severe thrombocytopenia and hypoxemia can limit to obtain deep tissue or bronchoalveolar lavage fluid to perform fungal culture. The low sensitivity of clinical and radiological signs can cause a significant delay in the accurate diagnosis of IA (1).

Detection of *Aspergillus* galactomannan (GM) antigen in serum by sandwich enzyme immunoassay method (Bio-Rad Laboratories, Marnes-la-Coquette, France) has been accepted as an important tool for the early diagnosis of IA. Although screening of high-risk hematology patients with the GM antigen was recommended in several guidelines, the performance of the test can be influenced by several factors such as duration of neutropenia, number of neutrophils, sampling schedule, incidence of IA, exposure to mold-active antifungal drugs, and laboratory experience (1, 2). The Turkish national expert report for the diagnosis of invasive fungal diseases (IFDs) recommended the GM antigen as a screening test based on the studies performed in different countries (3). There was only one study from Turkey regarding the GM antigen detection in high-risk hematology patients for the early diagnosis of IA when this report was written (4). Therefore, no country-specific recommendation could be made in the national expert report (3). The aim of the present study was to review the recently published national literature and to evaluate the role of GM antigen screening for the early diagnosis of IA in Turkish centers.

## MATERIALS and METHODS

PubMed was searched using the keywords “galactomannan” and “Turkey.” Only studies that investigated the performance of the GM antigen in adult patients as a screening test were included in the literature analysis.

## RESULTS

Four peer-reviewed articles from Turkey about the diagnostic performance of the GM antigen as a screening test for the diagnosis of IA were published at international journals between 2010 and 2018 and all of them included adult patients with different hematological malignancies or hematopoietic stem cell transplantation (HSCT) (4-7). Twice weekly sampling was performed in all studies. Screening tests were started at the day of an absolute neutrophil count

**Table 1.** Characteristics of the studies and diagnostic performance of galactomannan antigen

Study center Time period	Number of the patients	Number of the patients with IA	Number of the serum samples	Antifungal prophylaxis	Cut-off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Reference number
Hacettepe University 2001-2003	58 neutropenia episodes in 45 patients	1 proven 4 probable 20 possible EORTC/MSG 2002	545	None	Single positive results ODI $\geq$ 0.5 Two consecutive positive results ODI $\geq$ 0.5	100	5.7	9.1	100	4
Uludag University 2003-2004	165 neutropenia episodes in 106 patients	4 proven 11 probable 65 possible EORTC/MSG 2008	1385	Antifungal administration in 111 episodes, types of antifungal drugs were not stated	Single positive results ODI $\geq$ 0.5 Two consecutive positive results ODI $\geq$ 0.5	100	27.1	19.5	100	5
Osmangazi University 2008-2011	161 neutropenia episodes in 99 patients	1 proven 17 probable 60 possible EORTC/MSG 2008	358 from high risk patients and 20 from non-neutropenic patients without fever	Antifungal administration in 106 episodes, mold active drugs but exact types were not stated	Single positive results ODI $\geq$ 0.5	23.07	90.36	73.07	55.55	6
Erciyes University 2012-2013	75 neutropenia episodes in 64 patients	12 probable 1 possible EORTC/MSG 2008	354	Posaconazole in 31 episodes Fluconazole in 42 episodes Voriconazole in 2 episodes	Single positive results ODI $\geq$ 0.7	35.7	99.6	3.1	96.8	7

IA; invasive aspergillosis, EORTC/MSG; European Organization for Research and Treatment of Cancer/Invasive Fungal Infections Cooperative Group and the National Institute of Allergy and Infectious Diseases Mycoses Study Group, PPV; positive predictive value, NPV; negative predictive value, ODI; optical density index

of  $<500/\text{mm}^3$  until recovery of neutropenia except in Uludag University Hospital where GM screening started at the first day of hospitalization. The European Organization for Research and Treatment of Cancer/Invasive Fungal Infections Cooperative Group and the National Institute of Allergy and Infectious Diseases Mycoses Study Group (EORTC/MSG) criteria published in 2002 was used in the study performed at Hacettepe University Hospital to define the probability of IA (4, 8). Other studies used the EORTC/MSG criteria published in 2008 to define IA (5-7, 9).

A total of 301 adult patients with several hematological malignancies and 13 patients who underwent allogeneic HSCT were included in the four studies. Patients were followed up for 459 neutropenia episodes. GM antigen testing was performed in 2662 serum samples. Mold-active antifungal prophylaxis was administered in two studies (6, 7). Fluconazole was the choice of antifungal prophylaxis in other studies (4, 5).

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were 23.07%–100%, 5.7%–90.36%, 6.7%–73.07%, and 55.5%–100%, respectively (Table 1). Early diagnosis of IA by GM antigen screening was reported in only one patient (positive GM before detection of *Aspergillus* rhinosinusitis) in one of the four studies (4).

## DISCUSSION

The diagnostic performance of GM was highly variable between the centers. The sensitivity of the GM antigen was low in the first study from Turkey (4). This can be associated with the high rate of false-positive GM related to piperacillin-tazobactam (TZP) administration in the same center (10). The study from Uludag University Hospital showed a better performance contrast to the Hacettepe University study (Table 1), but there were still 65 patients with clinical and radiological findings concordant with IA (possible cases based

on the EORTC/MSG criteria) in which the GM antigen was negative despite screening twice a week (4, 5). Both centers did not use mold-active prophylaxis during the study periods, and false-positive GM related to TZP administration was not an issue in Uludag University (11). The debate on false-positive GM related to the administration of TZP (original brand) appeared to be resolved in Turkish centers, but false-positive GM in patients receiving a generic TZP was reported very recently (12-14). Obtaining the blood sample for GM antigen test just before the next dose of TZP was shown to be a very effective way for avoiding false positivity (15).

Previous studies reported very low sensitivity (23.07%–35.7%) for GM screening that was performed when posaconazole prophylaxis became the standard of care particularly for patients receiving induction chemotherapy for acute myeloid leukemia (AML) (6, 7). However, the specificity was higher than 90%, indicating that a positive GM result should trigger the diagnostic pathway for the early detection of IA (6, 7).

A total of 2972 serum GM tests were performed in a 4-year study with 262 unselected consecutive high-risk episodes that received posaconazole prophylaxis. GM antigen was negative in 96.7% of tests and 83.6% of episodes. There were 30 false-positive episodes that mainly occurred in tests performed as preemptive surveillance (26 out of these 30 episodes (86.7%)). When GM antigen testing was used for screening, PPV was 11.8%, whereas PPV increased to 89.6 when used a diagnostic test in case of suspicion of IFD. NPV remained at 100% at any scenario (16). While the sensitivity of GM in serum decreases under mold-active prophylaxis, GM antigen can remain positive in the bronchoalveolar lavage fluid despite posaconazole prophylaxis (17).

In a study from Erciyes University, the serum samples from patients with radiological evidence of IA and from patients without IA (1 to 10 ratio) were re-tested by a modified methodology that was previously proven to increase the sensitivity of GM antigen detection (7, 18). The sensitivity increased from 35.7% to 92.3% with a slight decrease in the specificity from 99.6% to 97.6% (7). The method is based on the concentration of GM antigen. It can be suitable for patients with radiological findings suggesting IA rather than a screening test due to high workload and extra cost.

Galactomannan (GM) antigen screening was supported as an early diagnostic tool for IA since 2001 and recommended by several guidelines as part of the routine care for patients with prolonged neutropenia (1, 2, 19). However, there are some studies not concordant with this statement. A previous study showed that GM antigen detection does not precede detection of major lesions by pulmonary computed tomography (CT) scan. The authors reported that only 7 (10%) out of 70 patients with pulmonary signs of IA have positive GM antigen test results before detection of the pathological change by CT scan (20). When the results of the randomized controlled study that compared voriconazole and amphotericin B in the treatment of IA were re-evaluated using the EORTC/MSG 2008 criteria, possible cases who received voriconazole had better outcomes than patients who received amphotericin B. The authors concluded that possible cases diagnosed by radiology without positive GM antigen or *Aspergillus* isolation are real aspergillosis diagnosed early by radiology (21). The rate of possible IFD (diagnosed by radiology without any microbiological evidence of IFD) was higher than that of probable IFD in the recent prospective European audit for invasive mold diseases that recruited patients

with AML and allogeneic HSCT. Only centers that have an immediate access to GM antigen testing were allowed to enroll patients in the study, and it was surprising that possible cases were more frequent despite serial GM screening in a prospective study (22). These findings raise questions about GM antigen screening for the early diagnosis of IA. A recent study from Switzerland analyzed the performance of the GM antigen as a screening tool in patients with hematological cancer with duration of neutropenia longer than 14 days. Serum GM antigen was measured two times per week, and mold-active prophylaxis was not routinely part of the care. IA was diagnosed in 30 out of 268 patients, and a positive serum GM was the first indicator of IA in 10 (33%) patients. A total of 500 GM antigen tests were required to diagnose one IA case based on GM antigen screening, costing \$15,000 in this setting (23). Cost and logistics are other important issues to use GM antigen screening as an effective tool for the early diagnosis of IA. The time period for reporting the results of GM antigen test was reported as 1 week from a Turkish university hospital (24).

There were also two pediatric studies investigating the role of GM antigen for the diagnosis of IA. The first study was from Ege University that included 141 patients with acute lymphoblastic leukemia followed up between 2006 and 2015. GM antigen was tested in 3264 serum samples. The authors did not calculate the sensitivity or specificity of GM antigen but investigated the role of GM antigen screening for the management of patients with neutropenia in detail. There were 5 patients with proven or probable IA. Of the 3264 serum samples, 179 (5.5%) from 76 patients were positive at a cut-off value of >0.5. Of the 76 patients, 21.7% were true positives, and 52.1% were false positives. Thorax CT scan revealed findings concordant with IA in 12 (15.8%) of the 76 patients with positive GM antigenemia. Of the 76 patients, 35 with positive GM antigen were already on mold-active antifungal therapy. The positive GM antigen results changed the antifungal treatment in only 13 (17.1%) patients (25). The second study included 47 hematological patients below 18 years old who had at least one GM antigen test result. A total of 158 blood samples were tested for GM antigen and yielded a sensitivity of 36% and a specificity of 90.9% at a cut-off value of 0.7. Decreasing the cut-off value for GM antigen to 0.5 increased the sensitivity to 68% but decreased the specificity to 77.2% (26).

## CONCLUSION

In Turkey, access to GM antigen test is available in most of the centers treating high-risk hematology patients, but publication of the experience in the international literature is limited (4-7, 25-27). Only one center reported GM antigen as a useful marker for the diagnosis of IA where mold-active prophylaxis was not used (5). After posaconazole prophylaxis was introduced in the clinical practice, the sensitivity of GM antigen was low, and the antifungal therapy was mainly triggered by radiological investigation (7). In addition, the benefit of GM antigen screening was extremely limited in pediatric patients (25, 26).

In conclusion, the performance of the GM antigen test as a screening tool is inferior in Turkish centers based on the findings of the limited number of studies. However, retaining GM antigen as a diagnostic test for patients with clinical and radiological findings suggesting IA will be useful to achieve microbiological signs about the etiology of suspected IFD.



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