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Infliximab Antibody Levels and Trough Concentration in Rheumatoid Arthritis: Exploring Therapeutic Response

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ABSTRACT

Background & Objective: Infliximab (IFX) is a chimeric monoclonal antibody that targets tumor necrosis factor-alpha (TNF-α) and is widely used in the treatment of autoimmune diseases, including rheumatoid arthritis (RA). However, therapeutic responses to infliximab vary among patients. The formation of anti-infliximab antibodies (AIA) may contribute to reduced efficacy and treatment failure. This study aimed to investigate the relationship between AIA formation, infliximab trough levels, and treatment response in patients with RA.

Materials & Methods: This cross-sectional study included 83 RA patients receiving infliximab (Remicade or Remsima) infusions at ≤ 6 months. Blood samples were collected prior to IFX infusion. Enzyme-linked immunosorbent assay (ELISA) kits were used to measure AIA, and infliximab trough concentration.

Results: Despite concurrent methotrexate therapy, many patients developed AIA (43.3 %). Infliximab trough concentration was higher in responders than non-responders but statistically not significant (*P-value*=0.114). Patients aged ≤40 years demonstrated a treatment response rate of 84.6%, compared with only 28.6% among those >60 years (*P-value* = 0.36). Additionally, male patients showed a higher response rate than females (*P-value* = 0.12).

Conclusion: The presence of AIA was associated with reduced treatment response in RA patients receiving infliximab. Higher infliximab trough levels correlated with better clinical outcomes. Age and sex may influence treatment efficacy, with younger patients and males showing better responses. Monitoring AIA and drug levels could help optimize therapeutic strategies in RA.

Keywords: Anti-infliximab Antibodies, Infliximab, Remicade, Remsima, Rheumatoid Arthritis, Serum Trough

1. Introduction

Rheumatoid arthritis (RA) is defined as a chronic autoimmune disease that primarily affects the articular structures (1, 2). The chronic inflammation associated with RA can cause damage to the joint tissues, leading to the destruction of cartilage and bone (3, 4).

TNF-α is considered the primary inflammatory cytokine involved in the pathogenesis of RA. Repeated administration of infliximab (IFX) demonstrated clinical benefit and effectively inhibited the progression of joint damage. Infliximab is a chimeric (human and mouse) monoclonal antibody against TNF-α (5-7). It is a biologic medication for rheumatoid arthritis. The chimeric monoclonal antibody infliximab inhibits tumor necrosis factor (TNF) binding to its cell-surface receptors (8, 9), then attenuates key features of chronic inflammation, including leukocyte recruitment and the production of pro-inflammatory mediators (10).

Despite its effectiveness, IFX can sometimes fail to yield positive clinical outcomes in patients with RA. This can be attributed to the developing of antidrug antibodies (ADAs) or other adverse effects (11, 12). The chimeric composition of IFX likely contributes to its immunogenicity (13, 14). Therapeutic drug monitoring involves monitoring for developing ADAs, which can arise in any patient as biological drugs' immunogenicity is an inherent characteristic. ADAs can enhance the clearance of IFX and tend to be primarily neutralizing in nature. The presence of ADAs has been linked to reduced response rates and treatment failure (15). Therefore, a therapy change is recommended to save money and prevent undesirable side effects, based on the above this

study aimed to assess the association between anti-infliximab antibodies and infliximab trough concentrations with clinical nonresponse in patients with rheumatoid arthritis.

2. Materials and Methods

This cross-sectional study was conducted in the Rheumatology Unit of Baghdad Teaching Hospital from September 2021 to April 2022. A total of 83 patients diagnosed with RA and treated with infliximab (Remicade® or Remsima®) for ≤6 months were enrolled. Patients were classified as responders (n=41) or non-responders (n=42) within six months of treatment initiation.

2.1 Inclusion criteria

Rheumatoid arthritis Patients on IFX treatment (two trademarks were using: Remsima and Remicade) at≤6 months of treatment.

2.2 Exclusion criteria

Rheumatoid arthritis patients with other autoimmune or chronic diseases, RA patient with any infections and malignancy. Anti-IFX antibodies and the IFX trough concentration were detected by enzyme-linked immunosorbent assay kit (My BioSource, USA). Clinical disease activity was assessed before infliximab infusion using the Clinical Disease Activity Index (CDAI). The CDAI was calculated as the sum of 28 tender and swollen joint counts plus patient and physician global assessments on a visual analog scale (VAS; 0–10). Patients were classified as responders if they achieved remission or low disease activity, and as nonresponders if they had moderate or high disease activity. CDAI categories were defined as follows: remission (<2.8), low disease activity (2.8–10), moderate disease activity (10–22), and high disease activity (>22). Informed consent was obtained from all participants.

2.3 Statistical analysis

The Statistical analyses were performed using SPSS software (v20.0; IBM, Armonk, NY) and GraphPad Prism (v7; GraphPad Software, San Diego, CA). A statistically significant difference was considered below or equal to 0.05.

3. Result

The study included 83 patients with rheumatoid arthritis, with a mean age of 49.6 years. Among them, 13 patients (15.7%) were younger than 40 years old, 36 patients (43.4%) were between 41 to 50 years old, 27 patients (32.4%) were aged between 51-60 years old, and seven patients (8.4%) were above 60 years old. The majority of the patients were females, with 66 patients (79.5%) being females and 17 patients (20.5%) males. Remsima and Remicade were the two trademarks used, with 63 patients (75.9%) on Remsima and 20 patients (24.1%) on Remicade treatment. Methotrexate was also administered to 60 (72.3%) RA patients.

The mean Remsima serum trough was 397.73 ng/ml, and, 1026.58 ng/ml for Remicade. The mean antidrug antibody levels were 63.38 ng/ml for anti-Remsima and 66.62 ng/ml for anti-Remicade.

The anti-drug Abs positivity was 49.4 % of RA patients. The present study observed the response to IFX among different age groups, the highest proportion of responders was found in the age group of ≤ 40 years with a *p-value* of 0.036. Regarding the sex, the response rate was 76.50% for males and 42.40% for females, with a *p-value* of 0.012.

There was a significant association between early response to infliximab and age group (p-value =0.036) and most responders in the age group ≤ 40 years as shown in Table 1. Regarding, the sex, the males were more responders than females (*p value*=0.012), Table 1.

The response rate for Remsima 44.40% and for Remicade was 65.00% treatment, with a p-value of 0.089. As well as the study revealed that the response rate for IFX with and without concomitant MTX were 40% and 73.9%. In addition, there was 51.20% of non-responder patients had ADA and 48.80% in responder patients, Table 2. The seropositivity of anti-IFX antibodies was 43.3% in the presence of MTX and 65.2% in its absence, Table 3. The trough concentration was classified as high and low in responder and non-responder patients as shown in Table 4.

On the other hand, this study showed no significant association between the positivity of anti-IFX and IFX trough concentration as shown in Table 5.

Table 1. The relationship between age and sex with the early clinical response to infliximab.

		Response		Total
		Nonresponder	**Responder**	
Age groups	≤ 40 years	2	11	13
		15.40 %	84.60 %	100.00 %
	41-50 years	19	17	36
		52.80 %	47.20 %	100.00 %
	51-60 years	16	11	27
		59.30 %	40.70 %	100.00 %
	>60 years	5	2	7
		71.40 %	28.60 %	100.00 %
Total		42	41	83
		50.60 %	49.40 %	100.00 %
p-value		**0.036***		
		Response		Total
		None	Response	
Sex	Female	38	28	66
		57.60 %	42.40 %	100.00 %
	Male	4	13	17
		23.50 %	76.50 %	100.00 %
Total		42	41	83
		50.60 %	49.40 %	100.00 %
p-value		**0.012***		

Table 2. The seropositivity of antidrug antibody in responders and nonresponses patients.

		Response		Total
		Non-responder	**Responder**	
Antidrug antibody	Positive	21	20	41
		51.20 %	48.80 %	100.00 %
	Negative	21	21	42
		50.00 %	50.00 %	100.00 %
Total		42	41	83
		50.60 %	49.40 %	100.00 %
p-value		**0.543**		

Table 3. The seropositivity of anti-IFX Abs according to the presence of MTX.

		Other treatment		Total	*p-value*
		MTX	**No**		
Antidrug antibody	Positive	26	15	41	0.061^{NS}
		43.3 %	65.2 %	49.4 %	
	Negative	34	8	42	
		56.7 %	34.8 %	50.6 %	
Total		60	23	83	
		100.0 %	100.0 %	100.0 %	

Methotrexate: MTX

Table 4. Association between trough concentration and response to IFX.

		Response		Total
		None	Response	
trough concentration	Low	25	18	0.114
		59.5 %	43.9 %	
	High	17	23	
		40.5 %	56.1%	
Total		42	41	83
		100.0 %	100.0 %	100.0 %

Infliximab: IFX

Table 5. Association between IFX trough concentration (classified as low and high) and antidrug antibodies.

		Antidrug Abs		Total	*p-value*
		Positive	**Negative**		
		100.0 %	100.0 %	100.0 %	
trough concentration	Low	22	21	43	**0.455**
		53.7 %	50.0 %	51.8 %	
	High	19	21	40	
		46.3%	50.0%	48.2 %	
Total		41	42	83	
		100.0 %	100.0 %	100.0 %	

Infliximab: IFX

4. Discussions

In this study, the mean age of patients with rheumatoid arthritis was 49.6 years, which is consistent with previous studies that reported similar average ages among RA populations **(16, 17)**.

The highest rate of RA was observed in the 41–50-year age group. The increase in autoantibody prevalence with aging can be attributed to the accumulation of tissue damage, which enhances exposure to apoptotic cells and self-antigens, thereby activating autoreactive lymphocytes **(18, 19)**.

Our results demonstrated that age plays a crucial role in the efficacy of anti-TNF-α therapy for RA. Specifically, the response rates to IFX were 84.60% and 28.60% in patients aged ≤ 40 years and >60 years, respectively, with a p-value of 0.036. The results indicated that older patients with RA had more severe disease and were less receptive to treatment than younger patients, as evidenced by their lower response rates to IFX. This finding is consistent with previous researches showing decreased effectiveness of anti-TNF-α therapy in patients over 65 **(20, 21)**. Despite the potential concerns about the effectiveness of

TNF inhibitors in elderly patients with RA, TNF inhibitors were still effective in treating RA and improving patient outcomes (22, 23). Regarding the sex, there was a sex variation in the susceptibility to RA, with the disease being more prevalent in females than males in a ratio of 4:1, this result was similar to study of Awni et al (24). Whereas the role of female hormonal factors in the development of RA remains unclear, however the higher prevalence of the disease in women is suggestive of its role (25, 26). Estrogen may increase the production of proinflammatory cytokines such as IL-1, IL-6, and TNF-α. Estrogens have been found to affect the immune system, particularly humoral immunity. As a result, females tend to have higher levels of circulating immunoglobulins than males (27).

According to the study results, there was a significant difference between males and females in their response to IFX treatment (*p-value*=0.012), with males showing a better response. Females may be more susceptible to developing anti-TNFI antibodies due to their enhanced immunogenicity and the proinflammatory effects of female sex hormones. These findings support the hypothesis that females with RA may be more likely to have the treatment-resistant disease, which can affect drug efficacy and tolerability (28, 29).

Almost half of the 83 studied patients who received a standard TNF-α blocker (IFX) regimen developed antibodies against the IFX therapy. Different studies revealed that many RA patients developed antibodies against IFX and some of them had an insufficient response to the treatment (30, 31).

Additionally, this study indicated that responders had higher IFX concentrations than non-responders. Similarly, other studies found that serum trough levels of IFX were higher in responders than non-responders (32, 33). ADA can form an immune complex with therapeutic drugs, which may increase drug clearance. Also, in this study the seropositivity of anti-IFX antibodies was 43.3% in the presence of MTX and 65.2 % in its absence. Dénarié et al (34) suggested that the co-administration of methotrexate, can prevent the development of anti-TNF antibodies. In RA patients treated with methotrexate, higher IFX trough concentrations were observed (34, 35). Finckh et al (36) reported that rheumatoid arthritis patients treated with methotrexate had higher trough concentrations of IFX and lower TNF-α levels than RA patients not treated with methotrexate. This may suggest that methotrexate can enhance the therapeutic effect of IFX in RA patients (36).

Present work revealed no statistically significant difference in the anti-TNF-α effect or immunogenicity between Remicade and its biosimilar Remsima. In other words, both drugs were equally effective in reducing inflammation and disease activity in patients with RA. Previous studies also reported no significant difference in immunogenicity between Remsima and Remicade in patients with RA (37, 38). A biosimilar biological drug (Remsima) has a similar amino acid sequence and specificity to the reference/original biological drug, in this case, IFX (Remicade).

5. Conclusion

In this study, patients with rheumatoid arthritis developed antibodies to infliximab despite the concurrent use of methotrexate. The presence of anti-infliximab antibodies (AIA) was associated with a reduced therapeutic response among patients receiving infliximab. Higher infliximab trough levels were correlated with improved clinical outcomes. Additionally, age and sex appeared to influence treatment efficacy, with younger patients and males demonstrating better responses. Regular monitoring of AIA and drug levels may help optimize therapeutic strategies and improve treatment outcomes in rheumatoid arthritis.

6. Declarations

6.1 Acknowledgments

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6.2 Ethical Considerations

All patients and the control group have given their consent. The study was approved by the Ethical Approval Committee. Ethical approval was obtained from the Institutional Review Board (IRB), College of Medicine at Al-Nahrain University (Approval No. REC1957, dated December 12, 2021). Written informed consent was obtained from all participants prior to their inclusion in the study.

6.3 Authors' Contributions

S.M.L.: Collection of samples, done the investigations and wrote the manuscript. A.A.A.: Conceived the study idea and supervised the project. M.H.A.: Collection of samples. All authors approved the final version of the manuscript and agreed to be accountable for the accuracy and integrity of the work.

6.4 Conflict of Interest

This study was conducted independently and received no external financial support. The research was fully self-funded by the authors.

6.5 Fund or Financial Support

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6.6 Using Artificial Intelligence Tools (AI Tools)

The authors were not utilized AI Tools.

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