Measurement of Serum Antibodies to Infliximab and Adalimumab

**Policy**

**Infliximab**
Measurement of antibodies to infliximab in a patient receiving treatment with infliximab, either alone or as a combination test, which includes the measurement of serum infliximab levels, is considered **investigational**.

**Adalimumab**
Measurement of antibodies to adalimumab in a patient receiving treatment with adalimumab, either alone or as a combination test, which includes the measurement of serum adalimumab levels, is considered **investigational**.

**Related Policies**

None

**Policy Guidelines**

<table>
<thead>
<tr>
<th>Medication generic and brand names</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generic name</strong></td>
</tr>
<tr>
<td>Adalimumab</td>
</tr>
<tr>
<td>Infliximab</td>
</tr>
</tbody>
</table>

**Coding**
Information from Prometheus Therapeutics and Diagnostics on Anser™IFX and Anser™ADA, state these serum antibody tests will be reported using one unit of the following CPT code:

- **CPT**
  - 84999 | Unlisted Chemistry Procedure
Infliximab (Remicade®, Janssen Biotech)
Remicade® is an intravenous tumor necrosis factor (TNF) α-blocking agent approved by the U.S. Food and Drug Administration (FDA) for the treatment of the following indications:

- Ankylosing spondylitis,
- Crohn disease (CD),
- Plaque psoriasis,
- Psoriatic arthritis,
- Rheumatoid arthritis (RA),
- Ulcerative colitis (UC)

Adalimumab (Humira®, AbbVie)
Humira® is a subcutaneous TNF-α inhibitor that is FDA-approved for the treatment of the following indications:

- Crohn disease (CD),
- Juvenile idiopathic arthritis,
- Ulcerative colitis [UC] in adults only

Following primary response to infliximab and adalimumab, some patients become nonresponders (secondary nonresponse). The development of antidrug antibodies is considered to be a cause of secondary nonresponse.

Background

Infliximab and adalimumab in autoimmune disease
Infliximab is a chimeric (mouse/human) anti-tumor necrosis factor α (TNF- α) monoclonal antibody. Adalimumab is a fully human monoclonal antibody to TNF- α. Therapy with monoclonal antibodies has revolutionized therapy in patients with inflammatory diseases such as inflammatory bowel disease (IBD; Crohn disease, ulcerative colitis), rheumatoid arthritis, and psoriasis. These agents are generally given to patients who fail conventional medical therapy, and they are typically highly effective for induction and maintenance of clinical remission. However, not all patients respond, and a high proportion of patients lose response over time. An estimated one-third of patients do not respond to induction therapy (primary nonresponse), and among initial responders, response wanes over time in approximately 20% to 60% of patients (secondary nonresponse). The reasons for therapeutic failures remains a matter of debate but include accelerate drug clearance (pharmacokinetics) and neutralizing agent activity (pharmacodynamics) due to ADA (1). ADA are also associated with acute infusion reactions (infliximab), injection site reactions (adalimumab) and delayed hypersensitivity reactions (infliximab). As a fully human antibody, adalimumab is considered less immunogenic than chimeric antibodies, such as infliximab.

Detection of Antidrug Antibodies (ADA)
The detection and quantitative measurement of ADA has been fraught with difficulty owing to drug interference and identifying when antibodies likely have a neutralizing effect. First-generation assays, (i.e., enzyme-linked immunosorbent assays [ELISA]) can measure only ADA in the absence of detectable drug levels due to interference of the drug with the assay. Other techniques available for measuring antibodies include the radioimmunoassay (RIA) method, and more recently, the homogenous mobility shift assay (HMSA) using high-performance liquid chromatography.

Disadvantages of the RIA method are associated with the complexity of the test and prolonged incubation time, and safety concerns related to the handling of radioactive material. The HMSA has the advantage of being able to measure ADA when infliximab is present in the serum. Studies evaluating the validation of results among different assays are lacking, making interstudy comparisons difficult. One retrospective study in 63 patients demonstrated comparable diagnostic accuracy between two different ELISA methods in patients with IBD, i.e., double antigen ELISA and antihuman lambda chain ELISA (2). This study did not include an objective, clinical and endoscopic scoring system for validation of results.
**Treatment options for patients with secondary loss of response to anti-TNF therapy**

A diminished or suboptimal response to infliximab or adalimumab can be managed in several ways: shortening the interval between doses, increasing the dose, switching to a different anti-TNF agent (in patients who continue to have loss of response after receiving the increased dose), or switching to a non-anti-TNF agent.

**Regulatory Status**

Clinical laboratories may develop and validate tests in-house and market them as a laboratory service; laboratory-developed tests (LDTs) must meet the general regulatory standards of the Clinical Laboratory Improvement Act (CLIA). Laboratories that offer LDTs must be licensed by CLIA for high-complexity testing. To date, the U.S. Food and Drug Administration has chosen not to require any regulatory review of this test.

Prometheus® Laboratories, a College of American Pathologists-accredited lab under CLIA, offers nonradiolabeled, fluid-phase HMSA tests called Anser™IFX for infliximab and Anser™ADA for adalimumab. Neither test is based on an enzyme-linked immunosorbent assay (ELISA) and each can measure antidrug antibodies in the presence of detectable drug levels, improving on a major limitation of the ELISA method. Both tests measure serum drug concentrations and antidrug antibodies.

**Scope**

Medical policies are systematically developed guidelines that serve as a resource for Company staff when determining coverage for specific medical procedures, drugs or devices. Coverage for medical services is subject to the limits and conditions of the member benefit plan. Members and their providers should consult the member benefit booklet or contact a customer service representative to determine whether there are any benefit limitations applicable to this service or supply. This medical policy does not apply to Medicare Advantage.

**Benefit Application**

N/A

**Rationale**

<table>
<thead>
<tr>
<th>Populations</th>
<th>Interventions</th>
<th>Comparators</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals: • With rheumatoid, psoriatic, or juvenile idiopathic arthritis; inflammatory bowel disease; ankylosing spondylitis; psoriasis</td>
<td>Interventions of interest are: • Evaluation for anti–tumor necrosis factor α inhibitor antibodies to infliximab or adalimumab</td>
<td>Comparators of interest are: • Usual care</td>
<td>Relevant outcomes include: • Test accuracy • Test validity • Change in disease status • Health status measures • Quality of life • Treatment-related morbidity</td>
</tr>
</tbody>
</table>

This policy was created in 2012 and has been updated annually. MEDLINE was searched through November 3, 2016, to identify literature assessing the analytic validity, clinical validity, and clinical utility of measuring serum ADA. Most studies evaluating antibodies to infliximab or to adalimumab report serum drug together with antidrug antibodies levels, and correlate levels to disease response. Serum drug levels and disease response will not be addressed in this policy and therefore the data reported on antidrug antibodies will be highlighted from the identified studies.

Most evidence concerning testing for ADA is derived from patients with inflammatory bowel disease (IBD) and rheumatoid arthritis (RA). There is less literature concerning other diseases including spondyloarthropathies (SpA) such as ankylosing spondylitis, psoriatic arthritis, IBD-related arthritis, reactive arthritis, some juvenile
idopathic arthritis and psoriasis.

**Analytic Validity**

**Measurement of Antibodies to Infliximab**

Wang et al. (2012) developed and validated a non-radio-labeled homogeneous mobility shift assay (HMSA) to measure ATI and infliximab levels in serum samples. (3) Full method validation was performed on both the ATI- and infliximab-HMSA, and the clinical sample test results were compared with those obtained from a bridging ELISA method to evaluate the difference in performance between the 2 assays. Intra- and inter-assay precision rates (as indicated by the coefficient of variation [CV]) for the ATI- and infliximab-HMSA were less than 4% and less than 15%, respectively, and less than 6% and less than 15%, respectively, considered to be robust. Hernandez-Breijo(4) described the use of the HMSA protocol in measuring ATI in 50 infliximab-treated Crohn disease (CD) patients, using methods similar to Wang et al.

Sera from 100 healthy subjects (blood bank donors) were tested to determine the assay cut points, defined to have an upper limit of approximately 97.5%. Using receiver operating characteristic analysis, a cut point of 1.19 μg/mL was calculated for ATI yielding a sensitivity of 95% (95% CI: 89 to 98) with a false positive rate of 3%. For serum infliximab levels, a cut point of 0.98 μg/mL was calculated; the false positive rate with this cut point was 5%.

One hundred serum samples that previously had tested positive with ELISA were reanalyzed by the new method. There was a high correlation between the 2 methods for ATI levels (p<0.001). The new method identified 5 false positive samples from the bridging ELISA method, thought to be due to a higher rate of nonspecific binding in the ELISA method.

In 2014, Steenholdt et al. published a post hoc comparison of different ATI assays. (5) Blood samples were collected from 66 (96%) of 69 patients enrolled in a randomized controlled trial (RCT) (discussed next) that assessed algorithmic treatment for Crohn disease (CD) relapse during infliximab therapy. (6) Samples were analyzed by 3 binding assays (RIA, ELISA, and HMSA) and by a reporter gene assay, a functional cell-based technique. ATI were detected in 18 patients (27%) by radioimmunoassay, 6 patients (9%) by ELISA, and 22 patients (33%) by HMSA. The reporter gene assay detected anti-infliximab activity, most likely due to ATI, in 7 patients (11%). As observed by the authors, this suggests that ATI detected by RIA and HMSA are not necessarily functionally active or neutralizing. Five patients (8%) were ATI-positive and 43 patients (65%) were ATI-negative by all 4 assays. Correlations were statistically significant (p<0.001) in all pairwise comparisons (r, 0.77 to 0.96). However, statistical agreement between assays could not be estimated accurately (e.g., using the intraclass correlation coefficient) because different assays reported values on different arbitrary scales. Regardless of the assay used, most patients (74% to 88%) had therapeutic serum infliximab levels and undetectable ATI, suggesting nonpharmacologic reasons for relapse or for symptoms mimicking relapse.

**Measurement of Antibodies to Adalimumab (ATA)**

Wang et al. (2013) developed and validated a nonradiolabeled HMSA to measure ATA and adalimumab levels in serum samples. (7) Analytic validation of performance characteristics (calibration standards, assay limits, intra- and interassay precision, linearity of dilution, substance interference) was performed for both the ATA- and adalimumab-HMSA. Because the elimination half-life of adalimumab (10-20 days) overlaps the dosing interval (every 2 weeks), ATA-positive sera to provide calibration standards were difficult to collect from patients. (The drug-free interval for antibody formation is short.) Therefore, antisera from rabbits immunized with adalimumab were pooled to form calibration standards. Serial dilutions of these ATA calibration standards then generated a standard curve against which test samples were compared. Over 29 experimental runs, intra-assay precision and accuracy for the adalimumab-HMSA (as indicated by the CV) were less than 20% and 3%, respectively; interassay (run-to-run, analyst-to-analyst, and instrument-to-instrument) precision and accuracy were less than 12% and less than 22%, respectively. For the ATA-HMSA, CVs for intra-assay precision and accuracy were less than 3% and 13%, respectively; CVs for interassay precision and accuracy were less than 9% and less than 18%, respectively. ELISA could not be used as a standard comparator due to competition from circulating drug.

Following evaluation of analytic validity of the a nonradiolabeled HMSA assay, Wang et al (2013) tested sera from 100 healthy subjects (obtained from blood bank donors) to determine the cut points of the assay, defined as the threshold above which samples were deemed to be positive with an upper limit of approximately 99%. The calculated cut point for serum adalimumab levels was 0.68 μg/mL, which yielded a false-positive rate of 3%. For
ATA, the calculated cut point was 0.55 U/mL, which yielded a false-positive rate of 1%. Analysis of 100 serum samples from patients who were losing response to adalimumab showed that 44% were above the cut point for ATA, and 26% were below the cut point for serum adalimumab level. In samples below the adalimumab cut point (0.68 μg/mL), 68% were ATA positive; in samples with adalimumab levels greater than 20 μg/mL, 18% were ATA-positive.

**Section Summary**
Analytic validity of ATI testing by homogeneous mobility shift assay was demonstrated using ELISA as a standard comparator. Test performance characteristics were considered robust. However, a subsequent comparative study identified substantial variability across ATI assay methods using a functional cell-based assay as standard. The pharmacokinetic properties of adalimumab (long half-life relative to dosing interval) prevented use of ELISA as a standard comparator in tests of analytic validity of ATA. Test performance characteristics were determined by comparison to a standard curve generated by serial dilutions of pooled rabbit antisera. Lack of comparison to an alternative method of antibody detection raises uncertainty about the analytic validity of the ATA test. The commercial Prometheus® HMSA assays do not suffer from many of the technical performance limitations of older assays; however, the HMSA assays do not distinguish neutralizing and non-neutralizing antibodies.

**Clinical Validity**
There is a substantial body of evidence examining associations of ADA with nonresponse and injection or infusion site reactions; numerous systematic reviews and meta-analyses have been published. Accordingly, the review of evidence concerning clinical validity focuses on the most current systematic reviews (Tables 1, 2, 3) and studies published subsequent to the search dates of those reviews (9) as well as relevant studies not included in identified reviews, for example those focusing on adverse reactions and ADA.

**Systematic Reviews and Meta-Analyses**
Five reviews published from 2012 through 2015 were identified. (8,10-13) The number of included studies ranged from 11 to 68, (12,13) varying according to review objectives and conditions of interest. Although not detailed here, there was considerable overlap in included studies across reviews.

Lee et al. (2012) conducted a meta-analysis of patients with IBD receiving infliximab to estimate the prevalence of ATI, effect of ATI on the prevalence of infusion reactions, and the effect of ATI on disease remission rates. (11) Databases were searched through October 2011, and 18 studies involving 3,326 patients were included. Studies included 9 RCTs, 5 prospective cohort studies, and 4 retrospective cohort studies. The prevalence of ATI was 45.8% when episodic infusions of infliximab were given and 12.4% when maintenance infliximab was given (Table 1). Patients with ATI were less likely to be in clinical remission (Table 2), but this was not statistically significant (RR=0.90; 95% CI, 0.79 to 1.02; p=0.10). The rates of infusion reactions were significantly higher in patients with ATI (relative risk [RR], 2.07 (Table 3); 95% confidence interval [CI], 1.61 to 2.67). Immunosuppressants resulted in a 50% reduction in the risk of developing ATI (P<0.001). The meta-analysis concluded that IBD patients who test positive for ATIs are at an increased risk of infusion reactions, but have similar rates of remission compared with patients who test negative for ATIs.

Nanda et al. (2013) conducted a meta-analysis of studies that reported on clinical outcomes according to the presence or absence of ATI in patients with IBD. (12) MEDLINE, Web of Science, Allied Health Literature (CINAHL) and Several databases were searched to February 2012, (1 to August 2012). Eleven studies involving 707 patients were selected. Six studies (2 RCTs, 1 prospective cohort study, 3 retrospective cohort studies) were included. In at least one quality domain (study eligibility criteria, measurement of exposure and outcome, control for confounders, completeness of follow-up), all the included studies had high risk of bias. The prevalence of detectable ATI in the included studies ranged from 22.4% to 46% (Table 1). The outcome of interest was loss of response to infliximab, defined as “relapse of clinical symptoms in patients who were in clinical remission from, or had responded to, infliximab.” Measures of loss of response varied across studies and included clinician assessment, standardized scales (Crohn’s Disease Activity Index [CDAI], Harvey Bradshaw Index, Simple Clinical Colitis Activity Index), and requirement for surgery or presence of non-healing fistula.

Patients with ATIs had a 3-fold greater risk of loss of response than those without ATIs (RR=3.2; 95% CI: 2.0 to 5.0) (shown in Table 1 as the RR of clinical response in treated vs. untreated patients to allow comparison with other meta-analyses). This result was influenced primarily by 532 patients with CD (RR=3.2; 95% CI: 1.9 to 5.5); pooled results for 86 patients with ulcerative colitis (UC) were not statistically significant (pooled RR=2.2; 95% CI: 1.0 to 4.8).
Garces et al (2013) performed a meta-analysis of studies of infliximab and adalimumab used to treat RA, IBD, SpA, and psoriasis. (10) Databases were searched to August 2012, and 12 prospective cohort studies included involving 860 patients (540 with RA, 132 with SpA, 130 with IBD, 58 with psoriasis). The outcome of interest was response, assessed by using standard assessment scales for rheumatologic diseases (e.g., European League Against Rheumatism criteria for RA; Assessment in Ankylosing Spondylitis 20% response criteria, or ASDAS for spondyloarthritis; Psoriasis Area and Severity Index for psoriasis) and clinician assessment for IBD. Overall, detectable ADA was associated with a 68% reduction in drug response (pooled RR=0.32; 95% CI: 0.22 to 0.48). Significant heterogeneity was introduced by varying use of immunosuppressant therapy (e.g., methotrexate) across studies. To assess anti-drug antibodies, most studies used RIA, which is less susceptible than ELISA to drug interference and may be more accurate.

A systematic review and meta-analysis by Thomas et al (2015) included 68 studies (total N=14,651 patients).(13) Patients had RA (n=8766), SpA (n=1534), or IBD (n=4351). Immunogenicity was examined for infliximab (39 comparisons), adalimumab(15), etanercept(5), golimumab(14), and certolizumab(8). Reviewers identified studies published through December 2013 and included 38 RCTs and 30 observational studies (study quality rated as good [n=32], moderate [n=26], poor [n=10]). The pooled prevalence of ADA varied by disease and drug (see Table 1, highest with infliximab: 25.3%). Duration of exposure (reported in 60 studies) was examined for its potential effect on the development of ADA, and most studies employed ELISA assays. The presence of ADA was associated with lower odds of response across most drugs and diseases (see Table 2). An exception was in studies of IBD (similar to that reported by Lee et al). Use of immunosuppressive agents substantially decreased the risk of ADA (odds ratio [OR], 0.26; 95% CI: 0.21 to 0.32). Finally, infusion reactions and injection-site reactions were more common (see Table 3) when ADA were detectable (OR=3.25; 95% CI, 2.35 to 4.51).

Evaluation of potential publication bias or overall assessment (eg, GRADE or similar) for the body of evidence was not reported. Additionally, no measures of heterogeneity were reported.

The systematic review by Meroni et al. (2015) searched Pubmed through March 2013 and included 57 studies of infliximab (n=34), adalimumab (n=18), and etanercept (n=5). (8) Studies included primarily patients with IBD and RA, but also SpA and psoriasis. Most studies were prospective cohort designs (n=42) and a formal assessment of study quality (bias) was not reported. The authors noted considerable variability in the time from drug administration to ADA and drug bioavailability testing across studies. Varied antibody testing assay methods were used including solid-phases RIA, traditional ELISA, fluid-phase RIA, and bridging ELISA; cutoffs for positive test results were also inconsistently reported. The ranges of patients with detectable ADA varied substantially (Table 1) but were consistent with other reviews. Qualitatively, the presence of ATI was associated with lower infliximab levels and lower risk of disease control or remission. The presence of ATI also increased the risk of infusion reactions. When ascertained, the time to development of ATI varied from as little as 16 weeks to over a year. The time to ATA positivity varied-e.g., 50% of patients with detectable ATA at 28 weeks to a median time of 1 year. Finally, for both infliximab or adalimumab immunosuppression was associated with less ADA positivity. The authors concluded that “the lack of homogeneity in study design and methodologies used in the studies analyzed limited the opportunity to establish the time-course and clinical consequences of anti-drug antibody development...” Although qualitative, the authors included many studies, and provided a detailed review of each study not reported by the other meta-analyses.

### Table 1. Estimated Prevalence of Antidrug Antibodies From Meta-Analysis

<table>
<thead>
<tr>
<th>Author</th>
<th>Included Studies</th>
<th>Drugs</th>
<th>Disease</th>
<th>Prevalence of ADA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IFX</td>
<td>ADL</td>
<td>IBD, RA, SpA</td>
</tr>
<tr>
<td>Lee (2012)</td>
<td>18</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Episodic</td>
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<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Maintenance</td>
<td>10</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Nanda (2013)</td>
<td>11</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Thomas (2015)</td>
<td>39</td>
<td>⬤</td>
<td>⬤</td>
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<tr>
<td></td>
<td>15</td>
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<td>⬤</td>
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<td>11</td>
<td>⬤</td>
<td>⬤</td>
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</tbody>
</table>
Table 2. Results From Meta-Analysis of Antidrug Antibodies and Clinical Response

<table>
<thead>
<tr>
<th>Author</th>
<th>Included Studies</th>
<th>Drugs</th>
<th>Disease</th>
<th>Clinical Response: ADA vs. None</th>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RR (95% CI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IFX</td>
<td>ADL</td>
<td>Other</td>
</tr>
<tr>
<td>Lee (2012)</td>
<td>18</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<td>Nanda (2013)</td>
<td>11</td>
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<td>Garces</td>
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<td>Thomas (2015)</td>
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<td></td>
<td>9</td>
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</tbody>
</table>

ADL: adalimumab; CI: confidence interval; IBD: inflammatory bowel disease; IFX: infliximab; NR: not reported; OR: odds ratio; RA: rheumatoid arthritis; RR: relative risk; SpA: spondyloarthropathy.

- Includes etanercept, golimumab, certolizumab.
- Number of comparisons in table; did not report studies for pooled prevalence.
- Also psoriasis.

Table 3. Increased Risk of Adverse Reaction Associated With the Presence of Antidrug Antibodies

<table>
<thead>
<tr>
<th>Author</th>
<th>Included Studies</th>
<th>Drugs</th>
<th>Disease</th>
<th>Adverse Reactions: ADA vs. None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IFX</td>
<td>ADL</td>
<td>Others</td>
</tr>
<tr>
<td>Lee (2012)</td>
<td>18</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<tr>
<td>Thomas (2015)</td>
<td>NR</td>
<td>•</td>
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</tr>
</tbody>
</table>

ADL: adalimumab; CI: confidence interval; IBD: inflammatory bowel disease; IFX: infliximab; NR: not reported; OR: odds ratio; RA: rheumatoid arthritis; RR: relative risk; SpA: spondyloarthropathy.

- Infusion reaction.

Cohort Studies

Three recent publications not included in a systematic review were identified. (14-16) Results were consistent with conclusions of the systematic reviews.

Arstikyte et al. (2015) prospectively evaluated the association of ADA with adverse events, clinical response, and drug levels in 143 symptomatic patients (62 with RA, 81 with SpA; mean age 45 years [SD=13]) treated with TNF blockers in Lithuania. (14) All patients receiving adalimumab or infliximab were tested and 1 of 3 patients given etanercept (because more commonly used). A response in RA patients was defined as either good, moderate, or low according to European League Against Rheumatism (EULAR) criteria (17); and SpA disease activity considered inactive, moderate, high, or very high according to established criteria (18) with inactive and moderately active disease defined as response. At least 3 months after therapy initiation, a single serum sample was obtained prior to dosing between January 2012 and December 2013; disease activity and other patient
characteristics (e.g., symptom duration, health status) were assessed concurrently. Serum adalimumab, infliximab, and etanercept levels were obtained; ADA was assayed using a bridging ELISA. Of 57 patients receiving infliximab, 14 (24.6%) had detectable antibodies with 13 of the 14 undetectable infliximab trough levels. Disease activity at baseline was unassociated with the development of ADA in either disease. In patients achieving response infliximab and adalimumab trough levels were higher, but not significantly (p=0.09 and p=0.14 respectively). Adalimumab concentrations were, however, higher in non-responders (p<0.001). Antibodies to infliximab were associated with infusion reactions but with little certainty (OR=5.9; 95% CI: 1.0 to 33.3) as was stopping infliximab treatment or changing agent. Study strengths include its prospective design, standardized assessments, and responder definition. Limitations involve the small number of non-responders and no indication whether any eligible participants declined enrollment.

Frederiksen et al. (2014) conducted a single-center retrospective cohort study of IBD patients treated with infliximab (n=187) or adalimumab (n=57) in Denmark. (15) ADA were assayed using fluid-phase RIA-49% of infliximab-treated patients developed antibodies compared with 21% of those treated with adalimumab. Development of antibodies to adalimumab was associated with secondary nonresponse-PPV 0.91 (95% CI: 0.59 to 1.0), sensitivity 0.50 (95% CI: 0.27 to 0.73), NPV 0.74 (95% CI: 0.57 to 0.87), specificity 0.97 (95% CI: 0.82 to 1.0) (with values varying according to adalimumab trough levels). The authors also reported that patients switching to adalimumab from infliximab who had antibodies were more likely to develop antibodies to adalimumab. The findings are consistent with other studies and evaluation of ADI using RIA (a strength of the study). However, conclusions are limited by the retrospective nature and sample size.

Jani et al. (2015) measured ADA by RIA together with drug levels in 331 RA patients treated with adalimumab (n=160) and etanercept (n=171) between November 2008 and March 2013. (16) Patients were participants in the Biologics in Rheumatoid arthritis Genetics and Genomics Study Syndicate conducted in 60 UK centers across the UK. Disease activity was assessed using the Disease Activity Score in 28 joints (DAS28) score. A response was evaluated using EULAR response criteria or changed DAS28 score. Following 12 months of adalimumab therapy, ADA were detectable in 24.8% of patients (almost all were detectable by 6 months) and were associated with lower drug levels. Both routine (non-trough) drug levels and antibodies to adalimumab were associated with DAS28 at 12 months. In predicting EULAR nonresponse, the AUC for adalimumab concentration less than 5 mg/mL at 3 months was 0.66 (95% CI: 0.55 to 0.77) and for presence of ADA 0.68 (95% CI: 0.54 to 0.81). None of the etanercept patients developed detectable ADA. Although derived from a well-established observational study designed to examine predictors (genetic and other) of treatment response, ADA levels were not used to inform treatment decisions. These results corroborate other study findings.

While many studies have evaluated clinical validity using single ADA measurements, at least one study assessed their persistence over time. Casteele et al. (2013) analyzed infliximab trough and ATI levels using an HMAS assay with banked serum obtained from 90 IBD patients treated between May 1999 and August 2011. (19) ATI levels had been previously assayed using an ELISA-based test. A total of 1,232 samples were evaluated (mean 14 per patient). Treatment decisions were made solely on clinical evaluation and CRP levels. ATI were detected in 53 of 90 (59%) of patients but subsequently were nondetectable in 15 of the 53 (28%). Persistent ATIs were associated with discontinuation of infliximab (RR=5.1; 95% CI: 1.4 to 19.0), but the wide confidence interval reflects considerable uncertainty. Although transience of ATI in IBD has not been carefully scrutinized, if replicated, these results suggest interpreting a single ATI result cautiously.

**Section Summary**

A large body of evidence has evaluated the clinical validity of ADA testing. ADA has been associated with secondary nonresponse in RA, SpA, but not clearly in IBD. The presence of ADA have been consistently associated with and increased risk of infliximab infusion and adalimumab injection site reactions. Concomitant use of immunosuppressant reduces the risk of developing ADA.

**Clinical Utility**

Several authors have published algorithms for management of patients with IBD(20-22) or RA(23) who relapse during TNF-inhibitor therapy. These algorithms are generally based on evidence, including that reviewed earlier, which indicate an association between antidrug antibodies, reduced serum drug levels, and relapse. None include evidence demonstrating improved health outcomes, such as reduced time to recovery from relapse (response), using algorithmic rather than dose-escalation approaches.

Aff et al (2010) evaluated the clinical utility of measuring ATI (referred to as human antichimeric antibodies
Record review from 2003 to 2008 identified 155 patients who had had ATI, had data on infliximab concentrations, and met the study inclusion criteria. A single physician ordered 72% of the initial tests. The authors retrospectively determined clinical response to infliximab. Forty-seven percent of patients were on concurrent immunosuppressive medication. The main indications for testing were loss of response to infliximab (49%), partial response after initiation of infliximab (22%), and possible autoimmune or delayed hypersensitivity reaction (10%). ATI were identified in 35 (23%) patients and therapeutic infliximab concentrations in 51 (33%) patients. Of 177 tests assessed, the results impacted treatment decisions in 73%. In ATI-positive patients, change to another anti-TNF agent was associated with a complete or partial response in 92% of patients, whereas dose escalation occurred in 17%.

The authors concluded that measurement of ATI and infliximab concentration impacted management and was clinically useful. Increasing the infliximab dose in patients with ATI was ineffective, whereas in patients with subtherapeutic infliximab concentrations, this strategy was considered a good alternative to changing to another anti-TNF agent.(24) Limitations to the study included its retrospective design and that the testing for antibodies to infliximab was performed using the enzyme-linked immunosorbent assay (ELISA) method. Because there was no control group in this study, it is not possible to determine what changes in management would have been made in the absence of ATI measurement. Clinicians are likely to make some changes in management for patients who do not achieve or maintain a clinical response, and it is important to understand how these management decisions differ when ATI are measured.

In 2014, Steenholdt et al. reported results of a noninferiority trial and cost-effectiveness analysis of 69 patients with CD who relapsed (CDAI ≥220 and/or ≥1 draining perianal fistula) during infliximab therapy.(6) Patients were randomized to infliximab dose intensification (5 mg/kg every 4 weeks) or algorithmic treatment based on serum infliximab level and ATI: Patients with subtherapeutic infliximab level (<0.5 μg/mL)(25) had infliximab dose increased if ATI were undetectable or were switched to adalimumab if ATI were detectable; patients with therapeutic infliximab level underwent repeat testing of infliximab and ATI levels if ATI were detectable or diagnostic reassessment if ATI were undetectable. Serum infliximab and ATI levels were measured in all patients by RIA in single-blind fashion (patients unaware but investigators aware of test results). Randomized groups were similar at baseline; overall, 55 (80%) of 69 patients had non-fistulizing disease. Most patients (70%) had therapeutic serum infliximab levels without detectable ATI; revised diagnoses in 6 (24%) of 25 such patients in the algorithm arm(26) included bile acid malabsorption, strictures, and IBS. In both intention-to-treat and per-protocol analyses, similar proportions of patients in each randomized group achieved clinical response at week 12, defined as a minimum 70-point reduction from baseline CDAI for patients with non-fistulizing disease and a minimum 50% reduction in active fistulas for patients with fistulizing disease (intention-to-treat: 58% in the algorithm group vs. 53% in the control group; p=0.810; per-protocol: 47% in the algorithm group vs. 53% in the control group; x² test, p=0.781). Only the intention-to-treat analysis fell within the prespecified noninferiority margin of -25% for the difference between groups.

Conclusions concerning noninferiority of an algorithmic approach compared with dose intensification from this trial are limited. The noninferiority margin was arguably large and was exceeded in the conservative per protocol analysis. Dropouts were frequent and differential between groups; 17 (51%) of 33 patients in the algorithm group and 28 (78%) of 36 patients in the control group completed the 12-week trial. A large proportion of patients (24%) in the algorithmic arm were potentially misdiagnosed (i.e., CD flare was subsequently determined not to be the cause of relapse); the comparable proportion in the control arm was not reported. In most patients (80% who had non-fistulizing disease), only a subjective measure of treatment response was used (minimum 70-point reduction from baseline CDAI).

Roblin et al. (2014) conducted a single-center, prospective observational study of 82 patients with IBD (n=45 CD, n=27 UC) with clinical relapse (CDAI >220 or Mayo Clinic >5) during treatment with adalimumab 40 mg every 2 weeks.(27) For all patients, trough adalimumab levels and ADA were measured in a blinded fashion using ELISA, and adalimumab dose was optimized to 40 mg weekly. Those who did not achieve clinical remission (CDAI <150 or Mayo score <2) within 4 months underwent repeat trough adalimumab and anti-adalimumab antibody testing and were switched to infliximab. Clinical and endoscopic responses after adalimumab optimization and after infliximab therapy for 6 months were compared among 3 groups:

1. Those with therapeutic adalimumab level (>4.9 μg/mL(28)),
2. Those with subtherapeutic adalimumab level and undetectable ATA; and
3. Those with subtherapeutic adalimumab level and detectable ATA.

After adalimumab optimization, more group 2 patients achieved clinical remission (16 [67%] of 24 patients) compared with group 1 (12 [29%] of 41 patients; p<0.01 vs. group 2) and group 3 (2 [12%] of 17 patients; p<0.01.
vs group 2). Duration of remission was longest in group 2 (mean [SD], 15 [5] months) compared with group 1 (mean [SD], 10 [4] months) and group 3 (mean [SD], 7 [3] months; log-rank test, \( p<0.01 \) for both comparisons vs. group 2). At 1 year, 13 (52%) of 24 patients in group 2 maintained clinical remission compared with no patients in group 1 or group 3 (\( p<0.01 \) for both comparisons vs. group 2). Results were similar when remission was defined using calprotectin levels (<250 \( \mu \)g/g stool) or endoscopic Mayo score (<2).

Fifty-two patients (n=30 CD, n=22 UC) who failed to achieve clinical remission after adalimumab optimization were switched to infliximab. More patients in group 3 achieved clinical remission (12 [80%] of 15 patients) compared with group 1 (2 [7%] of 29 patients) and group 2 (2 [25%] of 8 patients; \( p<0.01 \) for both comparisons vs. group 3). Duration of response after switch to infliximab was longest in group 3 (mean [SD], 14 [7] months) compared with group 1 (mean [SD], 3 [2] months) and group 2 (mean [SD], 5 [3] months; log-rank test, \( p<0.01 \) for both comparison vs. group 3). At 1 year, 8 (55%) of 15 patients in group 3 maintained clinical remission compared with no patients in group 1 or group 2 (\( p<0.01 \) for both comparisons with group 3). Results were similar using objective measures of clinical remission (calprotectin level and endoscopic Mayo score).

These results suggest that patients with IBD who relapse on adalimumab and have subtherapeutic serum adalimumab levels may benefit from increased adalimumab dose if ATA are undetectable or change to another TNF-inhibitor if ATA are detectable. Relapsed patients who have therapeutic serum adalimumab levels may benefit from change to another drug class. Strengths of the study are use of both subjective and objective measures of remission and blinded serum drug level and ATA monitoring. However, results are limited owing to the small sample size, use of ELISA for antibody testing, and lack of ADA levels for decision making. Subsequent study comparing the management using the algorithm proposed with usual care is needed. Ideally, more than one method of antibody assay would be used to further assess analytic validity. Finally, the first author of the paper received lecture fees from the ADA test provider (Theradiag).

**Section Summary**

Convincing evidence for the clinical utility of ADA testing currently is lacking. Uncontrolled retrospective studies in IBD demonstrate impacts of ADA testing on treatment decisions but cannot demonstrate improved patient outcomes compared with a no-testing strategy. Additional limitations of these studies include lack of clinical follow-up after treatment decisions were made in the Afif study(24) and use of clinical assessments to guide treatment decisions in the Steenholtst study(25). Additionally, determination of a clinically relevant threshold for ADA level is complicated by the use of various assay methods. A small, nonrandomized prospective study suggested that ADA levels may be informative in relapsed patients with IBD who have low serum adalimumab levels, but this finding requires confirmation in larger, randomized trials. Methodological flaws, including relapse misclassification limit conclusions from the RCT in patients with relapsed IBD. Direct or indirect evidence for clinical utility in RA or SpA was not identified. Finally, although ADA are associated with increased risk of infliximab infusion and adalimumab injection site reactions, whether testing for ADA can reduce that risk is unclear. For example, Lichtenstein et al. (2013) conducted a systematic review of infliximab-related infusion reactions and concluded “there is a paucity of systematic and controlled data on the risk, prevention, and management of infusion reactions to infliximab.” (22) They added that “[m]ore randomised controlled trials are needed in order to investigate the efficacy of the proposed preventive and management algorithms.”

**Summary of Evidence**

For individuals who have rheumatoid arthritis, psoriatic arthritis, or juvenile idiopathic arthritis; inflammatory bowel disease (Crohn disease, ulcerative colitis); ankylosing spondylitis; or plaque psoriasis who receive evaluation for anti-tumor necrosis factor \( \alpha \) inhibitor antibodies to infliximab or adalimumab, the evidence includes multiple systematic reviews, 1 randomized controlled trial (RCT), and observational studies. Relevant outcomes are test accuracy and validity, change in disease status, health status measures, quality of life, and treatment-related morbidity. Antibodies to infliximab (ATI) or to adalimumab (ATA) develop in a substantial proportion of treated patients and are believed to neutralize or enhance clearance of the drugs. Considerable evidence has demonstrated an association between antidrug antibodies (ADA) and secondary nonresponse as well as injection site and infusion reactions. The clinical usefulness of measuring ADA hinges on whether test results inform management changes, thereby leading to improved outcomes, compared with management directed by symptoms, clinical assessment, and standard laboratory evaluation. Limited evidence has described management changes after measuring ADA. A small RCT in patients with Crohn disease comparing ATI-informed management of relapse with standard dose escalation did not demonstrate improved outcomes with the ATI-informed approach. Additionally, many assays—some having significant limitations—have been used in studies; ADA threshold values that are informative for discriminating treatment responses have not been established. The
evidence is insufficient to determine the effects of the technology on health outcomes.

Ongoing and Unpublished Clinical Trials
Some currently unpublished trials that might influence this review are listed in Table 4.

Table 4. Summary of Key Trials

<table>
<thead>
<tr>
<th>NCT No.</th>
<th>Trial Name</th>
<th>Planned Enrollment</th>
<th>Completion Date</th>
</tr>
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<tbody>
<tr>
<td>Ongoing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>A Randomized, Multi-Center Biomarker Trial to Predict Therapeutic Responses of Patients With Rheumatoid Arthritis to a Specific Biologic Mode of Action</td>
<td>200</td>
<td>Jun 2017</td>
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<tr>
<td>Spondyloarthropathies</td>
<td>Effect of the Combination of Methotrexate and Adalimumab on Reduction of Immunization in Ankylosing Spondylitis (COMARIS)</td>
<td>110</td>
<td>Apr 2015</td>
</tr>
<tr>
<td>NCT01971918</td>
<td>Comparative Analysis of Two Therapeutic Strategies in Patients With Spondyloarthritis Treated With Anti-TNF Biologics (STRADA)</td>
<td>104</td>
<td>Nov 2016</td>
</tr>
</tbody>
</table>

NCT: national clinical trial.

Practice Guidelines and Position Statements

American College of Gastroenterology et al
Clinical guidelines from the American College of Gastroenterology (ACG),(29,30) the American College of Rheumatology (ACR),(31) and the European League Against Rheumatism (EULAR)(32) have not included recommendations for testing for antidrug antibodies (ADA) in patients treated with tumor necrosis factor (TNF) inhibitors. An important question included in the EULAR research recommendations was whether “measurement of serum drug and/or drug antibody levels [is] useful in clinical practice?”

National Institute for Health and Care Excellence
In 2016, the National Institute for Health and Care Excellence (NICE) issued guidance on therapeutic monitoring of TNF-α inhibitors in the treatment of patients with Crohn disease. (33) NICE recommends that laboratories monitoring TNF-α inhibitors in patients with Crohn disease who have lost response to the treatment, should work with clinicians to collect data through a prospective study, a local audit or a registry.

U.S. Preventive Services Task Force Recommendations
Not applicable.

Medicare National Coverage
There is no national coverage determination (NCD). In the absence of an NCD, coverage decisions are left to the discretion of local Medicare carriers.

References


Appendix

N/A

History

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<th>Date</th>
<th>Reason</th>
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</thead>
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<td>10/09/12</td>
<td>New Policy. Measurement of antibodies to infliximab, either alone or as a combination test which includes the measurement of serum infliximab levels, is considered investigational.</td>
</tr>
<tr>
<td>11/11/13</td>
<td>Replace Policy. Policy reviewed with literature search through July 2013; references 2, 6-12 added. Title changed to add “…and Adalimumab.” &quot;Measurement of antibodies to adalimumab in a patient receiving adalimumab, either alone or as a combination test which includes the measurement of serum adalimumab levels” added to the policy statement; considered investigational. Brand names added to policy for clarity.</td>
</tr>
<tr>
<td>12/08/15</td>
<td>Annual Review. Policy updated with literature review through September 30, 2015; references 1, 7-8, 12-18, and 30-32 added. Policy statements unchanged, although section titles added.</td>
</tr>
<tr>
<td>01/10/17</td>
<td>Annual Review. Policy updated with literature review through November 3, 2016; references 4 and 33 added. Policy statements unchanged.</td>
</tr>
</tbody>
</table>

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