**Measurement of Serum Antibodies to Infliximab and Adalimumab**

**Title:** Measurement of Serum Antibodies to Infliximab and Adalimumab

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<table>
<thead>
<tr>
<th>Populations</th>
<th>Interventions</th>
<th>Comparators</th>
<th>Outcomes</th>
</tr>
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<tbody>
<tr>
<td>Individuals:</td>
<td>Interventions of interest are:</td>
<td>Comparators of interest are:</td>
<td>Relevant outcomes include:</td>
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<tr>
<td>- With rheumatoid, psoriatic, or juvenile idiopathic arthritis; inflammatory bowel diseases; ankylosing spondylitis; psoriasis</td>
<td>- Evaluation for anti-tumor necrosis factor inhibitor antibodies to infliximab or adalimumab</td>
<td>- Usual care</td>
<td>- Test accuracy</td>
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<td>- Test validity</td>
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<td>- Change in disease status</td>
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<td>- Quality of life</td>
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<td>- Treatment-related morbidity</td>
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DESCRIPTION
Infliximab (Remicade) is an intravenous tumor necrosis factor α (TNF-α) blocking agent approved by the U.S. Food and Drug Administration (FDA) for the treatment of rheumatoid arthritis (RA), Crohn disease (CD), ankylosing spondylitis, psoriatic arthritis, plaque psoriasis, and ulcerative colitis. Adalimumab (Humira) is a subcutaneous TNF-α inhibitor that is FDA-approved for treatment of Crohn disease and ulcerative colitis in adults only-and juvenile idiopathic arthritis. Following primary response to infliximab and adalimumab some patients become nonresponders. The development of antidrug antibodies (ADA) is considered to be a cause of secondary nonresponse.

Objective
The objective of this evidence review is to evaluate whether testing of serum antibodies to infliximab and/or adalimumab in patients being managed with these drugs is associated with management changes and improved health outcomes.

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 for 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 remain a matter of debate but include accelerated drug clearance (pharmacokinetics) and neutralizing agent activity (pharmacodynamics) due to antidrug antibodies (ADA). ADA are also associated with injection-site reactions (adalimumab) and acute infusion reactions and delayed hypersensitivity reactions (infliximab). As a fully human antibody, adalimumab is considered less immunogenic than chimeric antibodies, like infliximab.

Detection of ADA (Antidrug Antibodies)
The detection and quantitative measurement of ADA is difficult, owing to drug interference and identifying when antibodies likely have a neutralizing effect. First-generation assays, (ie, 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 measures 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 2 different ELISA methods in patients with IBD (ie, double antigen ELISA and antihuman lambda chain-based ELISA). This study did not include an objective clinical and endoscopic scoring system for validation of results.

**Treatment Options for 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 non-radio-labeled, fluid-phase homogenous mobility shift assay (HMSA) tests called Anser™IFX (for infliximab) and Anser™ ADA (for adalimumab). Neither 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.

**POLICY**

A. 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 experimental / investigational.

B. 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 experimental / investigational.
RATIONALE
The MEDLINE database was searched through November 3, 2016, to identify literature assessing the analytic validity, clinical validity, and clinical utility of measuring serum antidrug antibodies (ADA). Most studies evaluating antibodies to infliximab (ATI) or to adalimumab (ATA) have reported serum drug together with ADA levels, and correlate levels to disease response. Serum drug levels and disease response will not be addressed in this evidence review, which focuses instead on the data reported on ADA.

Most evidence concerning testing for ADA is derived from the data available for patients with inflammatory bowel disease (IBD) and rheumatoid arthritis (RA). Less literature exists on other diseases comprising spondyloarthopathies (SpA; eg, ankylosing spondylitis, psoriatic arthritis, IBD-related arthritis, reactive arthritis, juvenile idiopathic 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. Full method validation was performed on both the ATI-HMSA and infliximab HMSA, and the clinical sample test results were compared with those obtained from a bridging enzyme-linked immunosorbent assay (ELISA) method to evaluate the difference in performance between the 2 assays. Intra- and interassay precision rates (as indicated by the coefficient of variation [CV]) for the ATI-HMSA and infliximab HMSA were less than 4% and less than 15%, respectively, and less than 6% and less than 15%, respectively, are considered to be robust. Hernandez-Breijo 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 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% confidence interval [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 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. Blood samples were collected from 66 (96%) of 69 patients enrolled in a randomized controlled trial (RCT) that assessed algorithmic treatment for CD relapse during infliximab therapy. Samples were analyzed by 3 binding assays (radioimmunoassay [RIA], ELISA, HMSA) and by a reporter gene assay (a functional cell-based technique). ATI were detected in 18 (27%) patients by RIA, in 6 (9%) patients by ELISA, and in 22 (33%) patients by HMSA. The reporter gene assay detected anti-infliximab activity, most likely due to ATI, in 7 (11%) patients. As observed by the authors; findings suggested that ATI detected by RIA and HMSA are not necessarily functionally active or neutralizing. Five (8%) patients were ATI-positive and 43 (65%) patients were ATI-negative by all 4 assays. Correlations were statistically significant (p<0.001) for all pairwise comparisons (r range, 0.77-0.96). However, statistical agreement between assays could not be estimated accurately (eg, using the intraclass correlation coefficient) because different assays
reported values on different arbitrary scales. Regardless of assay used, most patients (range, 74%-88%) had therapeutic serum infliximab levels and undetectable ATI, suggesting nonpharmacologic reasons for relapse or for symptoms mimicking relapse.

Measurement of ATA
Wang et al (2013) developed and validated a non-radio-labeled HMSA to measure ATA and adalimumab levels in serum samples. Analytic validation of performance characteristics (ie, calibration standards, assay limits, intra- and interassay precision, linearity of dilution, substance interference) was performed for both the ATA-HMSA 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 (ie, 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, 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 18%, respectively. ELISA could not be used as a standard comparator due to competition from circulating drug.

Following evaluation of the analytic validity of the non-radio-labeled HMSA assay, investigators 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, yielding 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
Analytic validity of ATI testing by HMSA has been 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 ATA analytic validity. 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 between neutralizing and non-neutralizing antibodies.
**Clinical Validity**

There is a substantial body of evidence (numerous systematic reviews and meta-analyses) examining associations between ADA and nonresponse as well as injection- or infusion-site reactions. Accordingly, our review of the evidence on clinical validity focuses on the most current systematic reviews (see Tables 1 through 3) and studies published subsequent to the search dates of those reviews, as well as relevant studies not included in identified reviews (eg, those focusing on adverse reactions and ADA).

**Systematic Reviews**

Five reviews published from 2012 through 2015 were identified. The number of studies included ranged from 11 to 68, varying by review objectives and conditions of interest. Although not detailed here, there was considerable overlap in selected 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. Databases were searched through October 2011, and 18 studies (total N=3,326 patients) were selected. 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 (see Table 1). Patients with ATI were less likely to be in clinical remission (see Table 2), but this was not statistically significant (relative risk [RR], 0.90; 95% CI, 0.79 to 1.02; p=0.10). Rates of infusion reactions were significantly higher in patients with ATI (RR=2.07; 95% CI, 1.61 to 2.67; see Table 3). Immunosuppressants resulted in a 50% reduction of the risk of developing ATI (p<0.001).

Reviewers concluded that patients with IBD who test positive for ATIs are at an increased risk of infusion reactions, but have rates of remission similar to 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. Several databases were searched to February 2012 (1 was searched to August 2012). Eleven 11 studies involving 707 patients were selected. Six studies (2 RCTs, 1 prospective cohort study, 3 retrospective cohort studies) were included. In at least 1 quality domain (study eligibility criteria, measurement of exposure and outcome, control for confounders, completeness of follow-up), all included studies had high risk of bias. The prevalence of detectable ATI in the included studies ranged from 22.4% to 46% (see 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 nonhealing 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, 0.5 to 9.0). (Eighty-nine patients with unspecified IBD also were included in the meta-analysis.) In addition to potential bias in included studies and heterogeneity in outcome assessment, the meta-analysis is limited by variability in the method of ATI detection (double-antigen ELISA, antihuman lambda chain–based ELISA, fluid-phase RIA).
Garces et al (2013) performed a meta-analysis of studies of infliximab and adalimumab used to treat RA, IBD, SpA, and psoriasis. Databases were searched to August 2012, and reviewers selected 12 prospective cohort studies 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 (eg, European League Against Rheumatism criteria for RA; Assessment in Ankylosing Spondylitis 20% response criteria, or Ankylosing Spondylitis Disease Activity Score for spondyloarthritis; Psoriasis Area and Severity Index for psoriasis) and clinician assessment for IBD. Overall, detectable ADA were 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 (eg, methotrexate) across studies. To assess ADA, 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). 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). Studies primarily included patients with IBD and RA, but also SpA and psoriasis. Most had prospective cohort designs (n=42) and a formal assessment of study quality (bias) was not reported. Reviewers noted considerable variability in the time from drug administration to ADA and drug bioavailability testing across studies. Various antibody testing assay methods were used and included 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 (see Table 1) but were consistent with other reviews. Qualitatively, the presence of ATI was associated with lower levels of infliximab 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 (eg, 50% of patients with detectable ATA at 28 weeks to a median time of 1 year). Finally, for both infliximab and adalimumab, immunosuppression was associated with less ADA positivity. The authors concluded that “...the lack of homogeneity in study design and methodologies used ... limited the opportunity to establish the time-course and clinical consequences of anti-drug antibody development....” Although qualitative, reviewers included many studies, and provided a detailed review of each 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>
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<tr>
<td></td>
<td></td>
<td>IFX</td>
<td>ADL</td>
<td>Other^a</td>
</tr>
<tr>
<td>Lee (2012) Episodic Maintenance</td>
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<td>Nanda (2013)</td>
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<td>Thomas (2015)</td>
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<td>15^c</td>
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ADA: antidrug antibodies; ADL: adalimumab; CI: confidence interval; IBD: inflammatory bowel disease; IFX: infliximab; RA: rheumatoid arthritis; SpA: spondyloarthritis.

^a Includes etanercept, golimumab, certolizumab.
^b Includes 3 studies including both maintenance and episodic therapy.
^c Number of comparisons in table; did not report studies for pooled prevalence.
^d Also psoriasis.

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>
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<tr>
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<td></td>
<td>IFX</td>
<td>ADL</td>
<td>Other^a</td>
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<td>●</td>
<td>●</td>
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ADA: antidrug antibodies; ADL: adalimumab; CI: confidence interval; IBD: inflammatory bowel disease; IFX: infliximab; OR: odds ratio; RA: rheumatoid arthritis; RR: relative risk; SpA: spondyloarthritis.

^a Includes etanercept, golimumab, certolizumab.
^b Also psoriasis.

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

<table>
<thead>
<tr>
<th>Author</th>
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<th>Drugs</th>
<th>Disease</th>
<th>Adverse Reactions: ADA vs None</th>
</tr>
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<tr>
<td></td>
<td></td>
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<td>ADL</td>
<td>Others^a</td>
</tr>
<tr>
<td>Lee (2012)</td>
<td>18</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Thomas (2015)</td>
<td>NR</td>
<td>●</td>
<td>●</td>
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</tr>
</tbody>
</table>

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

^a Infusion reaction.
Cohort Studies
Three recent publications not included in a systematic review were identified.\textsuperscript{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 serum drug levels in 143 symptomatic patients (62 with RA, 81 with SpA; mean age, 45 years) treated with TNF blockers in Lithuania.\textsuperscript{14} All patients receiving adalimumab or infliximab were tested and 1 in 3 patients was given etanercept (because it is more commonly used). A response in RA patients was defined as either good, moderate, or low using European League Against Rheumatism (EULAR) criteria\textsuperscript{17}; SpA disease activity was considered inactive, moderate, high, or very high by established criteria,\textsuperscript{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 2012 and 2013; disease activity and other patient characteristics (eg, 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). However, adalimumab concentrations were significantly higher in nonresponders (p<0.001). ATI 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 included its prospective design, standardized assessments, and responder definition. Limitations involved the small number of nonresponders 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.\textsuperscript{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 ATA was associated with secondary nonresponse: positive predictive value was 91\% (95\% CI, 59\% to 100\%), sensitivity was 50\% (95\% CI, 27\% to 73\%); negative predictive value was 74\% (95\% CI, 57\% to 87\%), and specificity was 97\% (95\% CI, 82\% to 100\%) (values varied by adalimumab trough levels). The authors also reported that patients switching from infliximab to adalimumab who had antibodies were more likely to develop ATA. These findings are consistent with other studies and evaluation of ADA using RIA (a strength of this study). Conclusions were limited by the retrospective design and sample size.

Jani et al (2015) measured ADA by RIA together with drug levels in 331 RA patients treated with adalimumab (n=160) or etanercept (n=171) between 2008 and 2013.\textsuperscript{16} Patients were participants in the Biologics in Rheumatoid Arthritis Genetics and Genomics Study Syndicate, conducted in 60 centers across the U.K. Disease activity was assessed using the Disease Activity Score in 28 joints (DAS28). A response was evaluated using EULAR response criteria or change in 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 (nontrough) drug levels and ATA were associated with DAS28 at 12 months. In predicting EULAR nonresponse, the area under the curve for adalimumab concentration less than 5 mg/mL at 3 months was 0.66 (95\% CI, 0.55 to 0.77) and 0.68 (95\% CI, 0.54 to 0.81) for
presence of ADA. 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. Study results corroborated other research findings.

While many studies have evaluated clinical validity using single ADA measurements, at least 1 study assessed their persistence over time. Vande Casteele et al (2013) analyzed infliximab trough and ATI levels using an HMSA assay with banked serum obtained from 90 IBD patients treated between 1999 and 2011.19 ATI levels had been previously assayed using an ELISA-based test. A total of 1232 samples were evaluated (mean, 14 per patient). Treatment decisions were made solely on clinical evaluation and C-reactive protein levels. ATI were detected in 53 (59%) of 90 patients but subsequently were nondetectable in 15 (28%) of the 53. 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 the transience of ATI in IBD has not been carefully scrutinized, if replicated, these results would suggest interpreting a single ATI result cautiously.

Section Summary: Clinical Validity
A large body of evidence has evaluated the clinical validity of ADA testing. ADA have been associated with secondary nonresponse in RA, SpA, but possibly IBD. The presence of ADA has been consistently associated with an increased risk of infusion-site reaction related to infliximab and injection-site reactions related to adalimumab. A concomitantly administered immunosuppressant agent reduces the risk of developing ADA.

Clinical Utility
Several algorithms have been developed for management of patients with IBD20-22 or RA23 who have relapsed during TNF-inhibitor therapy. These algorithms are generally based on evidence that has indicated an association between ADA, reduced serum drug levels, and relapse. None has included evidence demonstrating improved health outcomes, such as reduced time to recovery from relapse (response), using algorithmic rather than dose-escalation approaches.

Afif et al (2010) evaluated the clinical utility of measuring ATI (referred to as human antichimeric antibodies [HACA] in the study) and infliximab concentrations by retrospectively reviewing patient medical records.24 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 had a clinically useful effect on patient management. The strategy of increasing infliximab dose in patients with ATI was ineffective whereas in patients with subtherapeutic infliximab concentrations this strategy was a good alternative to changing to another anti-TNF agent.24 Study limitations
included the retrospective design and using ELISA testing for ATI. Because there was no control group, one cannot determine what changes in management would have been made absent ATI measurement. Because clinicians are likely to change management for patients who do not achieve or maintain a clinical response, 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. 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) 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 using 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 nonfistulizing 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 included bile acid malabsorption, strictures, and IBS. In both intention-to-treat (ITT) 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 nonfistulizing disease and a minimum 50% reduction in active fistulas for patients with fistulizing disease (ITT, 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; p=0.781). Only the ITT analysis fell within the prespecified noninferiority margin of -25% for the difference between groups.

Conclusions on the 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 (ie, 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 nonfistulizing 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. 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 across 3 groups: (1) those with a therapeutic adalimumab level (>4.9 μg/mL), (2) those with a subtherapeutic adalimumab level and undetectable ATA; and (3) those with a subtherapeutic adalimumab level and detectable ATA. After adalimumab optimization, more group 2 patients achieved clinical remission (16 [67%] of
24 patients) than 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) patients. Duration of remission was longest in group 2 (mean, 15 months) compared with group 1 (mean, 5 months) and group 3 (mean, 4 months; 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 groups 1 or 3 (p<0.01 for both comparisons vs group 2). Results were similar when remission was defined using calprotectin levels (<250 μg/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) than in group 1 (2 [7%] of 29 patients) or group 2 (2 [25%] of 8 patients; p<0.01 for both comparisons vs group 3). Duration of response after switching to infliximab was longest in group 3 (mean, 14 months) compared with group 1 (mean, 3 months) and group 2 (mean, 5 months; 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 groups 1 or 2 (p<0.01 for both comparisons vs group 3). Results were similar using objective measures of clinical remission (calprotectin level, endoscopic Mayo score).

These results suggested that patients with IBD who relapse on adalimumab and have subtherapeutic serum adalimumab levels may benefit from a higher adalimumab dose if ATA are undetectable or from a change to another TNF inhibitor if ATA are detectable. Relapsed patients who have therapeutic serum adalimumab levels may benefit from change to a different drug class. Strengths of the study include its use of subjective and objective measures of remission and blinded serum drug level and ATA monitoring. However, results were influenced by 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, using more than 1 method of assaying antibodies would further assessment of analytic validity. Finally, the lead author of the study received lecture fees from the ADA test provider (Theradiag).

Section Summary: Clinical Utility
Convincing evidence for the clinical utility of ADA testing currently is lacking. Uncontrolled retrospective studies in IBD have demonstrated the impact 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 Afif24) and lack of clinical assessments to guide treatment decisions (in Steenholdt25). 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. Methodologic flaws, including relapse misclassification, limit conclusions from the RCT in patients with relapsed IBD. Direct or indirect evidence for clinical utility in patients with 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 (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 He 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 α 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.

**Practice Guidelines and Position Statements**

**American College of Gastroenterology et al**

Clinical guidelines from the American College of Gastroenterology, the American College of Rheumatology, and the European League Against Rheumatism (EULAR) 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. 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 either a prospective study, a local audit, or a registry.

**U.S. Preventive Services Task Force Recommendations**

Not applicable.

**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

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<td>NCT01895764</td>
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<td>Immunization in Ankylosing Spondylitis (COMARIS)</td>
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NCT: national clinical trial.

**CODING**

The following codes for treatment and procedures applicable to this policy are included below for informational purposes. Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement. Please refer to the member’s contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

**CPT/HCPCS**

84999 Unlisted chemistry procedure

- According to materials from Prometheus on Anser™ IFX, and Anser™ ADA, these tests will be reported using 1 unit of CPT code 84999 (unlisted chemistry procedure).

**DIAGNOSES**

Experimental / investigational for all diagnoses related to this policy.

**REVISIONS**

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<td>- Added the indication of “B. Measurement of antibodies to adalimumab in a patient receiving treatment with adalimumab, either alone or as a</td>
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In Coding section:
• Updated coding comments

References updated

02-09-2016

Description section updated
Rationale section updated
References updated

05-10-2017

Description section updated
Rationale section updated
References updated

REFERENCES


