Removing Cerebrospinal Fluid Antibody Orders from the Test Menu Results in a Dramatic Decrease in Order Volume

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Background: Antibody tests for *Borrelia burgdorferi* (agent of Lyme disease), *Toxoplasma gondii*, and cytomegalovirus in cerebrospinal fluid (CSF) are rarely useful. One reason for misutilization of laboratory tests is simply the convenience offered by a computerized physician order entry (CPOE) system.
Methods: The cytomegalovirus (CMV) antibodies-CSF, *B. burgdorferi* antibodies-CSF, and *T. gondii* antibodies-CSF orders were removed from the test menu. A provider could still order these tests using a miscellaneous order. We collected monthly volumes of test orders before and after the tests were removed from the CPOE.
Results: Orders for CSF antibody testing for *B. burgdorferi*, *T. gondii*, and CMV decreased by 91%, 93%, and 98%, respectively ($P < 0.01$), after they were removed from the CPOE test menu. This result correlates to a savings of $50 053.44 per year. Additionally, we did not see a paradoxical increase in CMV PCR or *T. gondii* PCR orders after the intervention.
Conclusions: Removal of test orders from the CPOE dramatically decreased test order volume, which led to substantial cost savings and availability of CSF for more useful tests. There was no compensatory increase in order volume for related tests, indicating that providers were not looking for alternate tests.

IMPACT STATEMENT

At academic, tertiary care centers, the test menu in the computerized-order entry system gives providers the opportunity to order numerous tests at once. Removal of low-value tests from the test menu drastically reduces unnecessary utilization. Our study showed a >90% decrease in use of 3 tests, leading to an annual savings of greater than $50 000.

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[4] **Nonstandard abbreviations:** CPOE, computerized physician order entry; IT, information technology; EHR, electronic health record; CSF, cerebrospinal fluid; CMV, cytomegalovirus.

Laboratory tests are some of the most important and common aspects of patient care. It is estimated that 70% of medical decisions are based on laboratory tests (*1*) and $65 billion per year are spent to perform laboratory tests (*2*). Overutilization of laboratory tests can be harmful to patients by leading to misinterpretation and misdiagnosis, increased hospital length of stay, patient discomfort, and iatrogenic anemia. A 2014 survey of 1768 primary care physicians reported uncertainty in 14.7% of laboratory test orders (*3*). An estimated $6.8 billion dollars is spent on unnecessary testing and procedures (*4*).

Numerous methods have been identified as possible means to reduce unnecessary laboratory test orders. One such method involves computerized physician order entry (CPOE)[4] systems, which refer to systems that allow the provider to input orders for laboratory and other diagnostic tests, medications, and procedures directly into an electronic program. There are numerous benefits to the use of a CPOE, such as a decrease in medical errors and a contribution to a streamlined and efficient workflow (*5*–*8*). However, some studies suggest that the CPOE exacerbates inappropriate laboratory testing (*9*, *10*). Reasons for this are difficult to ascertain and could be due to laboratory tests with similar-sounding names, ease of selecting numerous laboratory tests, and order sets that include numerous laboratory tests prechecked. Studies have shown that laboratory test ordering patterns are influenced by requisition design (*11*) and use of panels and protocols (*12*, *13*). Clinical decision support, such as "pop-ups" and best practice alerts, have been shown to decrease unnecessary laboratory test orders (*14*, *15*). These can be difficult to implement since they must be built and tested by skilled information technology (IT) staff, may sometimes query the electronic health record (EHR) for previous laboratory or medication data, and may subject the user to "alert fatigue," a condition in which the provider becomes desensitized to further alerts and clicks as a result of pop-up messages that prevent him/her from completing the ordering process.

This study discusses a way to reduce testing for antibodies in the cerebrospinal fluid (CSF) for 3 organisms: *Borrelia burgdorferi*, *Toxoplasma gondii*, and cytomegalovirus (CMV). *B. burgdorferi* is a bacterium and causative agent of Lyme disease. It is transmitted through the bite of an infected tick and causes a diverse array and severity of clinical presentations. *T. gondii* is a parasite and patients are most commonly infected via ingestion of raw or undercooked meat or via transplacental transmission. CMV is a member of the herpesvirus family. All 3 of these organisms cause a wide spectrum of diseases, from asymptomatic presentation in immunocompetent patients to life-threatening disseminated disease in the immunocompromised, such as those undergoing chemotherapy treatment or who are infected with HIV.

Neurologic infections with these organisms are possible but relatively rare (*16*). Manifestations of all of these diseases are nonspecific; hence, these patients undergo testing for numerous diseases and infections simultaneously. CSF is obtained via an invasive and relatively high-risk procedure (lumbar puncture), and often a limited volume is obtained. Therefore, only the most useful tests should be ordered on this sample. Misuse via inappropriate laboratory tests can use up the sample, which could be used for more beneficial testing. In patients with neurologic disease caused by these organisms, antibodies are increased in peripheral blood, and therefore antibody testing in the CSF is often not helpful for diagnosis or management (*17*, *18*). The sensitivity of antibody testing in CSF for these organisms is not high enough to rule out this disease effectively when negative. Also, the presence of antibodies in CSF is not specific enough to diagnose neurologic infection because there is passage of antibodies from blood into the central nervous system. In rare cases of suspected toxoplasmosis or CMV infection, it is necessary to determine if the organism is in the

CSF, in which case PCR for the organism is the appropriate test (in addition to clinical findings and radiologic findings) (*19*, *20*). PCR for *B. burgdorferi* in CSF is not recommended.

METHODS

We noticed a high number of send-out laboratory tests ordered on CSF samples. After reviewing the number of orders and percent positivity for CSF antibody testing for *B. burgdorferi*, *T. gondii*, and CMV tests, we implemented the intervention, which was the removal of these orders from the CPOE system test menu. This step occurred in 2 phases: phase 1 was removal of the CMV antibodies-CSF order in December 2014, and phase 2 was removal of the *B. burgdorferi* antibodies-CSF and *T. gondii* antibodies-CSF orders in December 2015. A memo about *B. burgdorferi* went to all ordering providers in our hospital system before the intervention in phase 2. It stated the following:

> All,
>
> Effective immediately, CSF Lyme disease antibody testing is no longer orderable in Epic because this test is rarely useful. We sent out this test on 343 patients from UF Health in the previous 2 years. None of these patients were IgM positive, and 4 patients were positive for IgG only. None of these 4 patients had concomitant peripheral serology, and none were ultimately diagnosed with neuroborreliosis.
>
> In the very rare instance that you would like to order Lyme antibodies in CSF, you must use the "Miscellaneous Test" order in Epic. Please do NOT order spinal fluid testing on the existing blood orders in Epic.

We extracted test volumes and results of these orders from January 2013 to October 2016 for a total of 46 months. Because the change in the CPOE was completed in the middle of the month (December 2014 for CMV antibodies and December 2015 for *B. burgdorferi* and *T. gondii* antibodies), the volumes for the months of change were not included in either the before or after data analysis. For CMV, this step allowed analysis of 23 months before the change and 22 months after; for *T. gondii* and *B. burgdorferi*, this step resulted in data for 35 months before the change and 10 months after.

Additionally, for the same time period, we extracted volumes of orders for CMV and *T. gondii* PCR to serve as a benchmark for CSF testing for infectious diseases. These 2 orders are listed in the test menu in the CPOE, but *B. burgdorferi* PCR is not. No interventions were made regarding these tests.

All 3 of the antibody test orders were sent to Focus Diagnostics, and the PCR tests were sent to ARUP Laboratories. The cost per test is defined as the charge obtained by the referral laboratory from the host hospital. This definition does not reflect the charge displayed on a patient's bill or the amount submitted for reimbursement by an insurance program. Our CPOE is part of our EHR, which is Epic (Epic Systems). Each antibody test order included tests for IgG and IgM antibodies, so orders were only counted once (1 order equaled 2 results). *P* values were calculated using an unpaired *t*-test.

RESULTS

Results for monthly averages for all tests analyzed are summarized in Table 1. Table 2 shows the numbers of tests that were positive, negative, and not performed. Some orders were not performed due to insufficient quantity of the sample. Fig. 1 shows monthly volumes on a timeline.

B. burgdorferi

B. burgdorferi antibodies in CSF orders averaged 14.9 orders per month before the intervention, and 1.3 orders per month after the intervention for

Table 1. CSF antibody test orders.[a]

	Test	Before intervention			After intervention			*P* value	Difference from before and after per month	Cost per test ($)	Estimated monthly savings
		Average number of test orders per month (SD)	Range	Months of data collected	Average number of test orders per month (SD)	Range	Months of data collected				
Tests with interventions	*B. burgdorferi* IgG, IgM	14.9 (4.7)	7–27	35	1.3 (0.8)	0–3	10	<0.01	13.6	151.20	2056.32
	T. gondii IgG, IgM	13.5 (4.5)	6–23	35	0.9 (1.1)	0–3	10	<0.01	12.6	98.00	1234.80
	CMV IgG, IgM[b]	9.0 (4.0)[b]	2–21	23	0.2 (0.9)	0–4	22	<0.01	8.8	100.00	880.00
										Monthly total	$4171.12
Benchmarking tests	*T. gondii* PCR	3.6 (2.6)	0–11	35	3.6 (2.0)	1–8	10	>0.05			
	CMV PCR	19.7 (4.3)	10–29	23	17.6 (6.8)	9–32	22	>0.05			
										Yearly total	$50 053.44

[a] Average tests per month for antibody tests and benchmarking tests before and after the intervention are shown. Monthly costs per test are displayed, and an estimated monthly and yearly savings are calculated.
[b] All 4 of these orders were placed via the miscellaneous form in the first month after the intervention. These were discussed with the providers and not performed. There were no further requests for orders.

Table 2. Test results.[a]

Test	Number of orders and results +/−/not performed/total	Number of orders and results +/−/not performed/total
B. burgdorferi	Before (35 months)	After (10 months)
IgG	4/501/17/522	0/13/0/13
IgM	0/505/17/522	0/13/0/13
T. gondii	Before (35 months)	After (10 months)
IgG	21/433/17/471	0/9/0/9
IgM	1/453/17/471	0/9/0/9
CMV	Before (23 months)	After (22 months)
IgG	12/191/4/207	0/0/4/4
IgM	0/201/6/207	0/0/4/4

[a] Antibody test orders are broken down by individual IgG and IgM antibodies. In general, IgG antibodies indicated past infection, while IgM antibodies indicate acute or recent infection. The table also displays the number of tests not performed. The most common reason for not performing a test was insufficient quantity of the sample.

a decrease of 91% ($P < 0.01$). At a cost of $151.20, this leads to an estimated monthly savings of $2056.32. In all 45 months of analyzed data (535 total orders), there were no patients with positive IgM antibodies and 4 patients with positive IgG antibodies. Chart reviews were performed on these 4 patients. None of these patients had peripheral serology for comparison, and none of the patients were ultimately diagnosed with neuroborreliosis.

T. gondii

There was an average of 13.5 orders per month for *T. gondii* antibodies before the intervention and 0.9 orders per month after the intervention, representing a 93% decrease ($P < 0.01$). Each of these test costs $98, which amounted to an estimated $1234.80 in savings each month. In the entire 45 months (480 orders) of data analyzed, 21 patients were positive for IgG, and 1 patient was positive for IgM. This patient also had *T. gondii* PCR on the CSF sample, which was negative. This patient's chart was reviewed and the progress notes stated "Toxo:

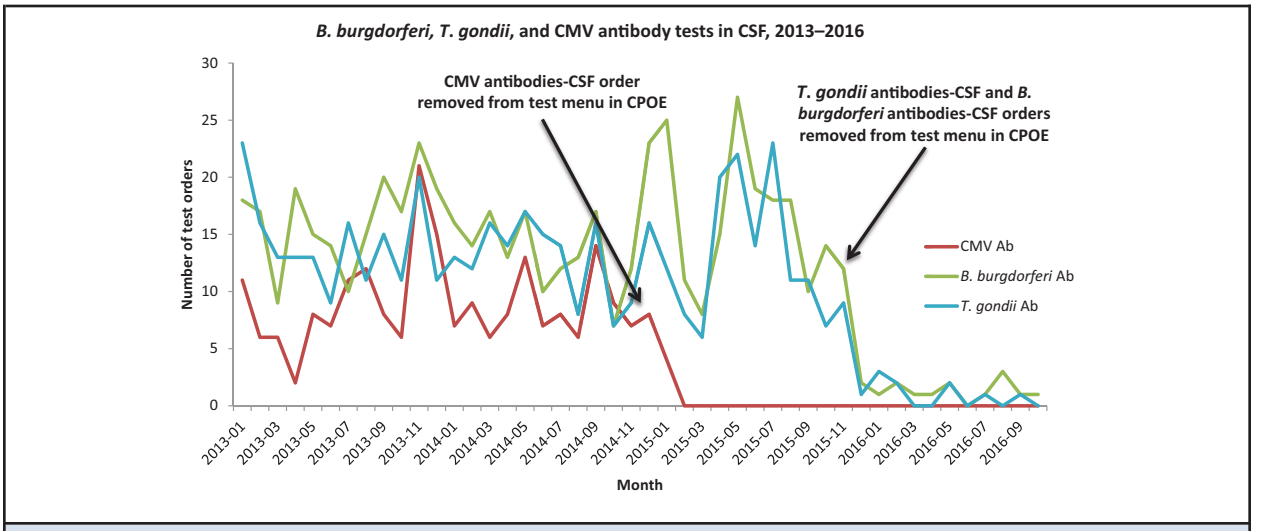

Fig. 1. Timeline of monthly volumes.
Arrows indicate when the tests were removed from the test menu in the computerized physician order entry system. Ab, antibody.

neg"; the antibody result was neither specifically discussed in any progress notes nor in the discharge summary. The etiology of this patient's disease was determined to be West Nile virus.

T. gondii PCR volumes averaged 3.6 orders per month both before and after the intervention. There was no intervention made to the CPOE for this order.

Cytomegalovirus

CMV antibodies in CSF orders averaged 9 orders per month before the intervention and 0.2 orders per month after the intervention: a decrease of 98% ($P < 0.01$). All of the 4 orders for this test that occurred after the intervention were in the first month after the change. These orders were discussed with the clinicians by a pathology resident and/or faculty and were determined to be unnecessary and were canceled. At $100 per test, the estimated monthly savings is $880. Out of 211 orders over the 45 months, 12 were positive for IgG and none were positive for IgM.

CMV PCR orders averaged 19.7 orders per month in the 23 months before the intervention and 17.6 orders per month after the intervention. This change was not statistically significant. There was no intervention made to the CPOE for this order.

DISCUSSION

Numerous methods have been described to decrease inappropriate laboratory test ordering (*5*, *6*, *14*, *21*). CSF antibody testing is often unnecessary and can actually be harmful to the patient due to wastage of a sample obtained via an invasive procedure. One of the most common reasons why an ordered test could not be performed in our study was insufficient quantity, so it is apparent that the volume of the CSF is often limited. Our study found that removal of these tests from the CPOE test menu led to a dramatic decrease in orders. This step did not compromise patient care since the appropriate test was still available and ordered consistently throughout the study period.

Our study adds to the growing literature regarding test utilization. One benefit to the intervention that we chose (removal from the test menu) is the

sheer simplicity of it. It requires a 1-time activity by an IT staff member with no active maintenance. While specialized skills within the IT department may be required for building complex pop-ups and other types of alerts (including those that query the medical record for past laboratory results and procedures), the removal of a test from a test menu is a relatively simple task that takes substantially less time. With limited resources in all areas of healthcare including IT, this was a straightforward way to obtain significant results. The labor costs are clearly justified, since we saved the institution an estimated $50 053.44 annually.

We continued to accept/receive orders for these CSF antibody tests via the miscellaneous order form, which is available in our CPOE. The form requires answering a series of questions such as test name and indication. It is possible that this was more cumbersome for our medical technologists in the send-out area of the laboratory since these miscellaneous orders are not part of a streamlined process (i.e., they do not come with barcoded labels and the order must be manually entered). However, in the postintervention period, we received an average of 2.4 tests per month (for all 3 organisms), compared with an average of 37 tests per month before the intervention. This step likely saved time on tasks such as preparing samples for shipping, making aliquots, and filing results, so the increase in miscellaneous orders was acceptable.

Other studies in the literature have shown paradoxical increases in tests related to the ones that were targeted with the intervention. For example, Rosenbloom et al. (*22*) described their experience with a CPOE intervention to decrease magnesium test orders. Providers placing the order were directed toward the patient's previous results and guidelines about laboratory testing, but could bypass the intervention by ordering magnesium as part of an order set that also included calcium and phosphorus. They saw significant increases in magnesium, calcium, and phosphorus orders due to the way this alert was set up. Therefore, we were pleased to see that the testing volumes for CMV and *T. gondii* PCR were stable throughout the study period; however, further research on the necessity of these tests is warranted. Perhaps it would be prudent to establish a best practice alert detailing clinical criteria or an algorithmic approach that substantiates the ordering of these tests.

Having data readily available was instrumental in this effort. Before removing the tests from the menu, a pathologist was easily able to pull the monthly order volumes using SAP BusinessObjects intelligence software (SAP AG), allowing us to identify the number of tests ordered and the percent positivity. We were then able to perform chart reviews on patients with abnormal test results. These data were later included in a memo to the entire hospital regarding *B. burgdorferi*, which provided extremely convincing evidence of inappropriate test utilization for this organism. Although we included our contact information in the email and welcomed questions and concerns, we did not receive any. Also, although we did not send out a memo specifically about CMV or *T. gondii*, we received very few questions about these orders and only in the first month after removal from the test menu. There are numerous sources of data regarding inappropriate testing including literature, guidelines, public health databases, and expert opinion. However, the most convincing source of data is one's own institution (*23*), in which case, the data reflect the provider's own patient population and his/her institution's ordering practices. We were confident that our intervention did not impede patient care because we had only 1 positive IgM in our historical data, which was a false positive according to the patient's chart. However, it was difficult to ascertain the impact of our email memo, i.e., what benefit would we have seen if we had sent the memo out with a recommendation, but did not remove the orders from the test menu? Other studies suggest that the impact of education alone degrades over time (*24*), but educational effort is certainly warranted.

The largest limitation of our study is that it was retrospective and nonrandomized. We studied an intervention that was designed to improve the quality of patient care and not modeled as a true research project. There are numerous downstream impacts on patient care that were not measured, such as discharge diagnosis, lumbar puncture complications, and hospital length of stay. We hypothesize that these would be improved by more appropriate utilization of the patient's CSF (i.e., lesser need to repeat the lumbar puncture for additional sample). Larger, more robust studies should be done to further improve laboratory test utilization, and these studies should address all specimen types, not limited to CSF alone. In conclusion, a relatively minor change to the CPOE test menu can have a substantial impact on test utilization and healthcare costs.

Additional Content on this Topic

Overriding Concerns: The Role of Electronic Medical Record–Based Best Practice Alerts in Reducing Unnecessary Laboratory Testing
David M. Lofthus, Jay Y. Gadgil, James A. de Lemos. Clin Chem 2015;61:456–8

Convincing Providers and Patients to Keep Testing Within Your Hospital and Laboratory's Utilization Management System
Michael Astion, CLN, April 2017

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