Value-based quality improvement projects for residents: Reducing unnecessary laboratory testing

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Abstract

Background: Medical costs are a leading financial concern for Americans, and medical providers must play an integral role in reducing cost of care by avoiding inappropriate laboratory testing. Residents and fellows can champion value-based quality improvement work to promote high quality patient care and reduce costs associated with unnecessary laboratory testing in their institutions. This narrative review of appropriate use of laboratory testing can direct trainee value-based quality improvement initiatives to reduce inappropriate testing in the inpatient, outpatient and emergency department setting.

Methods: In the 2017-2018 academic year, faculty mentors from the High Value Practice Academic Alliance compiled a list of laboratory tests to target for value-based quality improvement work. Under faculty mentorship, trainees contributed to this narrative review by reviewing relevant literature and providing recommendations for quality improvement targets for each of the proposed target laboratory tests.

Results: High Value Practice Academic Alliance faculty mentors identified 25 laboratory tests to target for value-based quality improvement work. These tests range the inpatient, outpatient and emergency settings and span several medical specialties.

Discussion: Trainees are poised to lead impactful value-based quality improvement initiatives. The present review provides trainees interested in this work with an actionable list of laboratory tests to target for optimization.

Introduction

The United States healthcare system is fraught with inefficiencies, with reports of $750 billion worth of waste contributing to poor quality, disparities, and patient harm[1]. Healthcare costs are a leading concern for families[2] and many adults forgo recommended care or avoid seeking care when ill due to cost[3]. To deliver higher value healthcare, many institutions are implementing quality improvement initiatives to reduce unnecessary tests, treatments and procedures. In academic medical centers, nearly two-thirds of laboratory testing in the inpatient setting does not affect patient management[4]. In addition to unnecessary costs and patient discomfort, inappropriate laboratory testing contributes to anemia, misguided management and unnecessary downstream testing.

As the front line providers in academic medical centers, trainees are especially poised to lead initiatives to reduce costs by reducing unnecessary laboratory testing across disciplines and care settings. The purpose of this narrative review is to provide trainees with an actionable list of laboratory studies to target for optimization as part of quality improvement efforts in the inpatient, outpatient and emergency department settings.

Methods

This narrative review is a collaborative effort among the faculty leaders and trainees engaged in the High Value Practice Academic Alliance in the 2017-2018 academic year. The High Value Practice Academic Alliance is an organization of faculty from 90 United States academic institutions with a mission to improve the quality and safety of patient care while reducing costs[5].

Participants collaborate on quality improvement, education and research in value-based care. Faculty leaders direct a trainee mentorship program, the Future Leaders Program[6].

To engage trainees in value-based scholarship in the 2017-2018 academic year, faculty compiled a list of laboratory tests to target for quality improvement. The list was generated through an emailed faculty survey conducted by a senior author (P.J.). Alongside a faculty mentor, trainees authored a synopsis for one or more of the targeted laboratory tests. Trainees reviewed relevant primary literature and existing guideline statements to inform a brief synopsis on overuse and appropriate indications for each laboratory test. Content experts reviewed synopses where necessary and three authors (J.T., P.J., and N.S.) compiled the review.

Results

High Value Practice Academic Alliance faculty leaders identified 25 laboratory tests as targets for optimization (Table 1). These tests crossed medical specialties and spanned the care continuum.

Chemistry

Basic and Comprehensive Metabolic Panel

The basic and comprehensive metabolic panels are frequently ordered for hospitalized patients without clear indication[4]. Repeated ordering of chemistries in the setting of clinical stability is recommended against[7]. In patients without clinical suspicion for hepatobiliary disease, carefully consider whether the additional data a comprehensive metabolic panel provides is necessary given the added cost.

Amylase in Pancreatitis

Combined with clinical features or characteristic imaging, elevated serum amylase or lipase can establish a diagnosis of acute pancreatitis. Amylase is less specific than lipase and can be falsely normal, particularly in alcohol- and hypertriglyceridemia-induced pancreatitis[8], limiting its utility. Testing both serum lipase and amylase in pancreatitis is discouraged because of increased cost without clinical benefit[9].

CK-MB

CK-MB was widely used before introduction of Troponin T and I, the current gold standard cardiac biomarker given high sensitivity and specificity for myocardial necrosis[10]. Previously, CK-MB was advocated to help diagnose reinfarction and used by some for diagnosis of peri-procedural infarction though troponin has subsumed that role. Routine use of CK-MB is not recommended[9,11–13].

Hematology

Complete Blood Count (CBC)

Ordering repetitive CBCs (with and without differential) in hospitalized patients in the setting of clinical and laboratory stability is not recommended[7]. Studies show reduction of routine use saves costs without negatively impacting quality of care[14,15].

Type and screen (TS)

There is currently no standard for determining the safe duration or validity of TS results in patients not pregnant or recently transfused[16]. For these patients, reordering a TS is likely unnecessary if ordered within the past three months. If a patient has received a transfusion, their history is unknown, or they have been pregnant in the past three months, the TS is valid only for three days[17].

Perioperative TS is often ordered inappropriately for minimally invasive or low-intermediate risk surgery. For operations with minimal anticipated blood loss, TS is likely unnecessary[18]. Implementation of a validated model to guide TS ordering for non-anemic pre-surgical patients could reduce unnecessary TS orders by up to 35%, without causing significant harm[19,20].

Peripheral blood smear

Manual review of peripheral blood smears by hematopathologists prompted by abnormalities detected on automated equipment is costly due to provider fees, volume and technician time[21,22]. The evolution of automated analyzers and middleware systems have reduced the volume of manual reviews[23] and efforts to improve accuracy of these systems to cut costs associated with manual reviews should be pursued[24]. International consensus criteria for manual peripheral blood

smear review have been attempted, however, there is great variability in the accuracy of these machines and each hospital should set their own standards for when hematopathologist review is required[25,26].

Thrombophilia Testing

In 2014, at least $300 million was spent on inpatient thrombophilia testing, which typically includes evaluating for Factor V Leiden, prothrombin gene mutation, and deficiencies of antithrombin, protein C, and protein S[27]. Identification of a heritable thrombophilia does not predict or reduce the risk of recurrent venous thromboembolism (VTE)[28]. Additionally, thrombophilia testing is difficult to interpret in acute VTE and while on anticoagulation[29]. Thrombophilia testing is recommended only in select patients with a first episode of unprovoked VTE in whom there is a plan to stop anticoagulation[30,31] and is not recommended for adults with a provoked VTE[32]. If indefinite anticoagulation is planned, testing is of limited utility[27].

Heparin-induced Thrombocytopenia (HIT) Testing

HIT is an immune-mediated reaction to heparin that can lead to thromboembolism. Inappropriate testing for HIT in low risk patients is performed frequently in US hospitals; up to 60% of tests were not appropriate in one retrospective study[33]. The 4 T's score is a well-validated tool to classify patients as low, intermediate, and high risk for HIT. Intermediate and high-risk groups warrant further laboratory testing[34,35].

Folic acid

Folic acid levels are often measured in anemia[36] and in the workup of dementia, delirium, and peripheral neuropathy[37,38] despite the dramatic decline in folate deficiency in the US since

mandatory fortification of processed grains was instituted. Multiple studies have documented the overuse of folic acid testing[38–40]. Empiric supplementation for suspected folate deficiency is more cost effective than a test-and-treat strategy. If testing is required, serum folic acid is recommended over RBC folate[9].

Endocrine

Triiodothyronine (T3)

Nearly 60% of total serum T3 and free T3 (FT3) levels orders are inappropriate[41]. For a host of biochemical reasons, measuring T3 is of limited utility and indicated only in select diagnostic circumstances including along with TSH and FT4 for diagnosing hyperthyroidism in pregnancy, diagnosing TSH-secreting pituitary adenoma, and follow-up after initiation of anti-thyroid drugs or radioactive iodine ablation[42,43]. T3 should not be ordered as initial testing for suspected thyroid disease or to monitor levothyroxine dosing[44]. Employing algorithms that reflex thyroid hormone testing only when the TSH is abnormal present an additional opportunity for cost savings[45].

Vitamin D Screening

There is insufficient evidence to recommend screening asymptomatic adults for vitamin D deficiency because no consensus exists regarding a level at which replacement provides clinical benefit[46]. Among those at high risk for deficiency, namely those with osteoporosis, chronic kidney disease, malabsorption, obesity and some infections, screening with 25-hydroxyvitamin D is recommended[9]. There are few indications for measuring 1,25-dihydroxyvitamin D and testing in the absence of hypercalcemia or renal insufficiency is not recommended[44].

Gastroenterology

Fecal Lactoferrin

Fecal lactoferrin is a highly sensitive biomarker of active neutrophils and is useful to distinguish intestinal inflammation from non-inflammatory bowel disease, such as irritable bowel syndrome, though is not specific for exact cause of intestinal inflammation[47–49]. In patients with inflammatory bowel disease, fecal lactoferrin can assess disease activity and degree of mucosal healing non-invasively and can predict relapse and response to therapy[48]. Fecal calprotectin is used similarly and may offer better test characteristics[50]. As they often provide the same clinical information, routine testing of both fecal lactoferrin and calprotectin is not indicated.

Fecal Occult Blood Testing (FOBT)

FOBT is a validated outpatient colorectal cancer screening tool but is often misused in the acute setting to evaluate gastrointestinal bleeding (GIB)[51]. They are of two types: guaiac-based tests measuring heme (gFOBT), and immunochemical tests (FIT) measuring globin. FOBT cannot identify bleeding acuity and can be positive with clinically insignificant esophagitis, epistaxis, or certain foods. FIT testing is more specific for GIB, but is less sensitive for upper GIB since globin becomes denatured in the upper tract[51]. When used inappropriately in the acute setting, the indirect costs of delay in care, unnecessary testing and prolonged hospitalization are high[51]. Instead of FOBT, GIB should be evaluated with history, physical exam including digital rectal exam, hemoglobin, BUN, and iron store measurement[52,53].

Helicobacter pylori Serology

Helicobacter pylori infection is common, particularly in the developing world, and can lead to peptic ulcer disease, GIB, and gastric malignancy. Available diagnostics include serology, endoscopy, breath tests, and fecal antigen tests. Serology is the least effective owing to poor test characteristics and inability to determine chronicity of infection[54] and is not recommended for diagnosis of *H. pylori* infection[9]. Fecal antigen testing is the preferred testing strategy[54].

Infectious Diseases

Hepatitis A Virus (HAV) Serology

Routine infant vaccination has reduced HAV incidence in the US. Vaccination of high risk adults is also recommended[55] and some advocate pre-vaccination screening in high-prevalence groups as a cost-effective approach to HAV prevention, assuming the cost of a single test is not greater than the vaccine series[56]. Testing for HAV in acute hepatitis among otherwise healthy, previously vaccinated patients is unlikely to aid diagnosis because immunity persists for 15-25 years following vaccination[57]. In patients without known immunity, anti-HAV IgM antibody could be considered in the evaluation of severe acute liver injury[58].

Hepatitis B Virus (HBV) Serology

Screening for HBV is cost effective given the burdens associated with reactivation of chronic infection, cirrhosis and hepatocellular carcinoma[59]. Screening high-risk individuals, including vulnerable healthcare personnel, with hepatitis B surface antigen, surface antibody and core antibody is recommended[59]. Hepatitis B serologic testing is complex, and inappropriate testing is frequently performed. One study found a substantial number of laboratory orders for anti-HBe

antibody and HBeAg, which have no role in the routine screening for HBV immunity or infection[60].

Hepatitis C Virus (HCV) Viral Load and Genotype

HCV viral load can diagnose acute infection, establish chronic infection in antibody-positive patients, and monitor response to treatment. A viral load is not an appropriate screening test for chronic HCV. For patients with chronic HCV, viral load testing is indicated at diagnosis and to monitor response to treatment, however, is not recommended at other times. In patients with sustained virologic response after treatment, a viral load is only necessary for a new exposure or unexplained hepatic dysfunction. Genotype testing is only indicated if treatment with a non-pan-genotypic regimen is planned[61].

Gastrointestinal Pathogen Nucleic Acid Amplification Test (NAAT) Panels

Most cases of acute infectious diarrhea are self-limited and routine diagnostics are discouraged unless *Clostridioides (Clostridium) difficile* infection (CDI) is suspected[62]. Gastrointestinal-specific NAAT panels rapidly identify pathogens including viruses, bacteria and parasites with sensitivity and specificity of >90% and >97%, respectively, though can pose high cost to patients and institutions. These panels do not distinguish between colonization and infection, so clinically irrelevant pathogens can be detected[62,63]. Without concern for CDI, testing should be reserved for patients with a history of recent travel, those at risk for severe disease, and those with greater than seven days of symptoms[64]. Understanding the consequences of testing is important, as treating a generally self-limited process comes at additional cost and side effects[62].

CDI Testing

C. difficile is the leading cause of nosocomial infectious diarrhea among adults and is rising in children. CDI testing is recommended for unexplained, new-onset diarrhea of three or more unformed stools in 24 hours. In settings without established criteria for patient stool submission, an initial stool toxin test as part of a multistep diagnostic algorithm is preferred over NAAT alone owing to the high rate of false positives for NAAT, though both are acceptable. Testing asymptomatic patients and tests of cure are not recommended. Due to high rate of colonization, infants under 12 months should not be tested. Among children 1 to 2 years of age, testing can be considered after excluding other causes of diarrhea. After age 2, testing should be performed as it would be for adults[65].

Rapid Antigen Testing and Culture for Group A Streptococcal Pharyngitis

Viruses cause the majority of outpatient cases of pharyngitis. Group A *Streptococcus* (GAS) accounts for 10%-30% of pharyngitis in children and 5-15% in adults[66]. GAS pharyngitis is treated to prevent acute rheumatic fever (ARF). GAS testing is not indicated for children <3 years old without risk factors, such as sibling contact, due to the extremely rare occurrence of ARF in this age group. Due to risk of ARF in children, back-up throat culture when RAT is negative is indicated. Among adults, routine use of back-up culture is not recommended due to lower incidence of GAS and lower risk of ARF[66]. It is not necessary to submit a positive swab for confirmatory culture at any age given high specificity of RAT. Follow-up post treatment throat cultures are not routinely recommended[66].

Legionella pneumophila Urinary Antigen Testing (UAT)

Legionella pneumophila causes fewer than 2% of non-epidemic community acquired pneumonia cases annually[67]. *Legionella* pneumonia is clinically differentiated through its extrapulmonary manifestations, including relative bradycardia, headache, confusion, diarrhea, transaminitis, and hyponatremia[68]. While the sensitivity and specificity of *Legionella* UAT, which detects 80% of serogroup 1, is improving, the low pretest probability of *Legionella* pneumonia limits its utility[69]. *Legionella* UAT should be limited to severe pneumonia, immunocompromise, characteristic extrapulmonary manifestations, critical illness, failure of outpatient antibiotic therapy, active alcohol abuse, travel within the past two weeks or presence of a pleural effusion[70].

Inflammatory Conditions

C-Reactive Protein (CRP) and Erythrocyte Sedimentation Rate (ESR)

CRP is an acute phase reactant that responds quickly to inflammation. The ESR is a surrogate marker of the acute phase reaction but is affected by plasma albumin concentration, size, shape and number of red blood cells, and non-acute phase reaction proteins[71]. ESR can be negative in minor inflammation, takes longer to become elevated during an inflammatory process, and takes longer to clear once inflammation resolves[9]. CRP is a better marker of the acute phase reaction in nearly all inflammatory processes, with some exceptions such as low-grade musculoskeletal infections and some autoimmune diseases. CRP is preferred over ESR to detect acute phase inflammation[9].

Antinuclear Antibody (ANA) and Sub-Serologies

ANA testing is used to evaluate suspected autoimmune disease, however, is falsely positive in up to 15% of healthy adults[72]. With few exceptions, if ANA is negative, ANA sub-serologies are

also negative. Despite this, one U.S. medical center found 6.6% of ANA tests had at least one sub-serology tested simultaneously[73]. The financial implications of indiscriminate ANA testing are significant[74.] Testing ANA sub-serologies with a negative ANA and low pretest probability of immune-mediated disease is not recommended[72].

Paraneoplastic Panel

Paraneoplastic encephalitis typically manifests acutely or subacutely, can precede cancer diagnosis by weeks to months, is often associated with cerebrospinal fluid pleocytosis, elevated protein, oligoclonal bands and elevated immunoglobulins[75,76]. Serum and cerebrospinal fluid panels are available to measure several antibodies associated with paraneoplastic encephalitis syndromes but inappropriate ordering results in a high number of false positives and unnecessary costs related to follow-up care[75]. Positive antibody tests in the absence of clinical features of paraneoplastic encephalitis is of limited utility and the absence of these antibodies does not preclude the diagnosis in the appropriate clinical situation[75,76].

Drug monitoring

Tacrolimus level

Tacrolimus is used in nearly all solid organ transplants[77]. Inpatient tacrolimus drug monitoring (TDM) is standard of care but variable pharmacokinetics, absorption, and medication interactions limit the utility and reliability of inpatient monitoring[77]. Further, the timing of inpatient TDM is unreliable, resulting in an estimated $22 million dollars in waste each year[78]. The impact of inpatient TDM needs to be clarified and inpatient-specific guidelines developed.

Discussion

In this review, we identify 25 target laboratory tests for ordering optimization that span medical specialties and the care continuum. By improving appropriate use of laboratory tests across the clinical spectrum, medical providers can reduce waste and improve healthcare value. While our review is limited by the informal methodology, we have compiled an actionable summary to inform value-based quality improvement work in academic medical centers across the nation.

Implementing value-based quality improvement and education to reduce the unnecessary ordering of laboratory tests among housestaff has been successful[79–81] and is a focus of nationwide campaigns including Choosing Wisely®[82] and specialty-specific initiatives, such as the American College of Physicians and Alliance for Academic Internal Medicine High Value Care Curriculum[83].

Engaging housestaff in the leading these initiatives is beneficial to patient care, institutions and to trainee career development. The involvement of residents in the planning, implementation and evaluation process of value-based quality improvement work has been successful in optimizing care while providing the trainee with valuable experience leading this work[84,85]. Aligning trainee value-based quality improvement projects with institutional priorities supports high quality patient care and the educational mission of academic medical centers[85,86]. Further, trainee involvement in value-based initiatives fulfills the Accreditation Council for Graduate Medical Education's requirement for quality improvement work[87].

Medical providers must improve ordering appropriateness as part of the national imperative to reduce waste and increase healthcare value. Engaging trainees in this work facilitates successful implementation and serves to ingrain principles of high value care into their practice. Our review is a resource for trainees interested in championing this vital work in their own institutions by providing actionable targets for quality improvement projects.

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Abbreviations used:
CBC: Complete blood count
TS: Type and screen
VTE: Venous thromboembolism
HIT: Heparin-induced thrombocytopenia
TSH: Thyroid stimulating hormone
T3: Triiodothyronine
FT3: Free T3
GIB: gastrointestinal bleed
FOBT: fecal occult blood test
BUN: Blood urea nitrogen
HAV: Hepatitis A virus
HBV: Hepatitis B virus
HCV: Hepatitis C virus
CDI: *Clostridioides (Clostridium) difficile* infection
NAAT: nucleic acid amplification test
GAS: Group A *Streptococcus*
ARF: Acute rheumatic fever
RAT: rapid antigen test
UAT: Urinary antigen test
CRP: C-reactive protein
ESR: Erythrocyte sedimentation rate
ANA: Antinuclear antibody
TDM: tacrolimus drug monitoring

Table 1. Proposed laboratory tests with appropriateness improvement targets.

Laboratory test	**Appropriateness Improvement Target**
Amylase	Replace with lipase for diagnosis of acute pancreatitis.
Antinuclear Antibody and Sub-Serologies	Do not test for ANA sub-serologies in the setting of negative ANA and low pretest probability of autoimmune disease.
Basic Metabolic Panel	Eliminate repeated testing in the setting of clinical and laboratory stability.
Complete Blood Count	Eliminate repeated testing in the setting of clinical and laboratory stability.
CK-MB	Eliminate in favor of troponin for diagnosis of acute coronary syndrome.
Clostridiodes difficile Testing	Do not test asymptomatic patients and do not perform test of cure. Routine testing in infants is not recommended.
Erythrocyte Sedimentation Rate	Eliminate in favor of C-reactive protein in most cases of acute inflammation, except low-grade bone and joint infections and some autoimmune diseases.
Fecal Lactoferrin	Do not use both fecal lactoferrin and calprotection routinely given similar test characteristics.
Fecal Occult Blood Testing	Eliminate use in the evaluation of suspected acute gastrointestinal bleeding.
Folic acid	Favor empiric supplementation over testing. If testing is necessary, serum folate is favored over RBC folate.
Gastrointestinal Pathogen Nucleic Acid Amplification Panels	Limit use to those with a recent travel history, those with increased risk of severe disease and those with symptoms persisting beyond seven days.
Helicobacter pylori Serology	Eliminate use of *H. pylori* serology in the evaluation of active infection.
Heparin-Induced Thrombocytopenia	Avoid testing for patients with low probability for HIT.

Hepatitis A virus screening	In otherwise healthy individuals known to be immune, avoid measuring HAV antibodies in the diagnosis of acute hepatitis.
Hepatitis B virus screening	Screen high risk individuals with Hepatitis B surface antigen, surface antibody, and core antibody only.
Hepatitis C viral load and genotype	Limit HCV viral load testing to diagnosis of acute and chronic HCV infection and monitoring of an antiviral regimen. Genotypes are only necessary when treatment with a non-pan-genotypic agent is planned.
Legionella pneumophila Urinary Antigen Testing	Avoid use in typical community-acquired pneumonia.
Paraneoplastic panel	Avoid in cases with low pretest probability of paraneoplastic encephalitis.
Peripheral Blood Smear	Optimize automated systems to avoid unnecessary triggers for hematopathologist review.
Rapid Antigen Testing for Group A Streptococcal Pharyngitis	Avoid testing in the setting of obvious viral illness. In adults, routine back-up culture is not recommended. Test of cure not routinely recommended.
Tacrolimus Level	Optimize timing of drug levels in the inpatient setting.
Thrombophilia Work-up	Eliminate for most inpatients, for those with provoked venous thromboembolism, and among those for whom indefinite anticoagulation is otherwise indicated.
Total Serum Triiodothyronine and Free T3	Not recommended for diagnosis of thyroid disorders except in pregnancy, TSH-secreting pituitary adenoma or follow up after administering medications or radioactive iodine ablation.
Type and Screen	Avoid retesting in < 3 months (unless pregnant or transfused) and reduce use in the perioperative setting for non-anemic patients undergoing low-risk procedures.
Vitamin D Deficiency Screening	Screen only high risk patients with 25-hydroxyvitamin D. Avoid 1,25-dihydroxyvitamin D in the absence of hypercalcemia or renal insufficiency.