SYSTEMATIC LITERATURE REVIEW ON THE MANAGEMENT OF SURGICAL SITE INFECTIONS

Adopted by the American Academy of Orthopaedic Surgeons Board of Directors
June 9, 2018

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Disclaimer

This Systematic literature review was developed by an AAOS physician volunteer Systematic literature review development group based on a systematic review of the current scientific and clinical information and accepted approaches to treatment and/or diagnosis. This Systematic literature review is not intended to be a fixed protocol, as some patients may require more or less treatment or different means of diagnosis. Clinical patients may not necessarily be the same as those found in a clinical trial. Patient care and treatment should always be based on a clinician's independent medical judgment, given the individual patient's clinical circumstances.

Disclosure Requirement
In accordance with AAOS policy, all individuals whose names appear as authors or contributors to Systematic literature reviewfiled a disclosure statement as part of the submission process. All panel members provided full disclosure of potential conflicts of interest prior to voting on the recommendations contained within this Systematic literature reviews.

Funding Source
This Systematic literature review was funded exclusively by the American Academy of Orthopaedic Surgeons who received no funding from outside commercial sources to support the development of this document.

FDA Clearance
Some drugs or medical devices referenced or described in this Systematic literature review may not have been cleared by the Food and Drug Administration (FDA) or may have been cleared for a specific use only. The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or device he or she wishes to use in clinical practice.

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SUMMARY OF RECOMMENDATIONS

MEDICAL IMAGING

Limited evidence supports the use of medical imaging in the diagnostic evaluation of patients with a suspected organ/space (i.e. bone, joint, and implant) surgical site infection.

Strength of Recommendation: Limited ★★☆☆

*Description: Evidence from two or more "Low" quality studies with consistent findings **or** evidence from a single "Moderate" quality study recommending for or against the intervention or diagnostic test or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.*

CULTURES

Strong evidence supports that synovial fluid and tissue cultures are strong rule-in tests for the diagnosis of infection; negative synovial fluid and tissue cultures do not reliably exclude infection.

Strength of Recommendation: Strong ★★★★

Description: Evidence from two or more "High" strength studies with consistent findings for recommending for or against the intervention.

C-REACTIVE PROTEIN

Strong evidence supports that C-reactive Protein is a strong rule-in and rule-out marker for patients with suspected surgical site infections.

Strength of Recommendation: Strong ★★★★

Description: Evidence from two or more "High" strength studies with consistent findings for recommending for or against the intervention.

ERYTHROCYTE SEDIMENTATION RATE

Limited strength evidence does not support the use of ESR, alone, to rule in and rule out surgical site infections due to conflicting data.

Strength of Recommendation: Limited ★★☆☆

*Description: Evidence from two or more "Low" quality studies with consistent findings **or** evidence from a single "Moderate" quality study recommending for or against the intervention or diagnostic test or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.*

CLINICAL EXAM FOR THE DIAGNOSIS OF SURGICAL SITE INFECTIONS

Moderate strength evidence supports that clinical exam (i.e. pain, drainage, fever) is a moderate to strong rule-in test (i.e. high probability of presence of infection, if test is positive) for patients with suspected surgical site infections, but a weak rule-out test.

Strength of Recommendation: Moderate ★★★☆

Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.

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STRONG EVIDENCE OF FACTORS ASSOCIATED WITH INCREASED RISK OF SSI

Strong evidence supports that the following factors are associated with an increased risk of infection:

- **Anemia**
- **Duration of Hospital Stay**
- **Immunosuppressive Medications**
- **History of Alcohol Abuse**
- **Obesity**
- **Depression**
- **History of Congestive Heart Failure**
- **Dementia**
- **HIV/AIDS**

Strength of Recommendation: Strong 

Description: Evidence from two or more "High" strength studies with consistent findings for recommending for or against the intervention.

MODERATE EVIDENCE OF INCREASED ASSOCIATED RISK OF SSI

Moderate strength evidence supports that patients meeting one or more of the following criteria are at an increased risk of infection after hip and knee arthroplasty

- **Chronic Kidney Disease**
- **Diabetes (conflicting evidence)**
- **Tabacco Use/Smoking (conflicting evidence)**
- **Malnutrition (conflicting evidence)**

Strength of Recommendation: Moderate 

Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.

LIMITED EVIDENCE OF INCREASED ASSOCIATED SSI RISK

Limited strength evidence supports that patients meeting one or more of the following criteria are at an increased risk of infection after hip and knee arthroplasty:

- **Cancer (conflicting evidence)**
- **Hypertension (conflicting evidence)**
- **Liver Disease (conflicting evidence)**

Strength of Recommendation: Limited 

*Description: Evidence from two or more "Low" quality studies with consistent findings **or** evidence from a single "Moderate" quality study recommending for or against the intervention or diagnostic test or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.*

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ANTIBIOTIC DURATION FOR MANAGEMENT OF SURGICAL SITE INFECTIONS

Moderate evidence supports that, in the setting of retained total joint arthroplasty, antibiotic protocols of 8 weeks do not result in significantly different outcomes when compared to protocols of 3 to 6-month duration.

Strength of Recommendation: Moderate 

Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.

RIFAMPIN USE FOR MANAGEMENT OF SURGICAL SITE INFECTIONS

Moderate evidence supports that rifampin, as a second antimicrobial, increases the probability of treatment success for staphylococcal infections in the setting of retained orthopaedic implants.

Strength of Recommendation: Moderate 

Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.

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INTRODUCTION

OVERVIEW

A systematic review of the English language published studies was conducted to include management of surgical site infections strictly following AAOS guidelines for systematic reviews, the findings from which were the basis if the Clinical Practice Guidelines CPG that are presented here. As with any systematic review, data were included or excluded in light of how they were generated. Observations of occurrences and relationships that appear in cases or case series add to experiential knowledge but cannot be used as a foundation to broad recommendations that extend beyond anecdotal circumstances. Study methodologies are important to generate valid data, including defining and isolating the studied effect, preventing sampling and observer bias and mathematically appropriate analysis. Deficiencies in study design weaken the validity of the data, lowering the level of evidence and weakening the strength of related recommendation. When experimental design leads to data that truly supports a cause and effect relationship, those findings require confirmation from other studies before they can be relied upon as medical knowledge used in patient care decisions. In addition to providing practice recommendations, this systematic review also highlights limitations in the literature and areas that require future research.

GOALS AND RATIONALE

The purpose of this CPG is to provide care providers with an up to date summary and analysis of the credible evidence related to the management of SSI available as of June 2017, so that sound clinical decisions can be based on best evidence to afford their patients the highest possible quality of care and best possible treatment outcomes within individual circumstances. The purpose of the CPG is not to replace clinical judgement or compromise the care needed by individual patients. The data published on management of SSI spans all subspecialties of orthopaedics, other areas of clinical medicine and basic science, however, the majority of the data that was included by the rules use to conduct the systematic review came from the arthroplasty literature, notably hip and knee reconstruction. The findings identify clinical areas where there is good evidence, where evidence is lacking, and where future research is needed. It is emphasized that many data may only be applicable to the specific conditions of the study from which they were generated while other data can contribute to general principles and concepts. It is expected the individual providers will use their expertise, experience and clinical judgement when they apply findings from this systematic review and recommendations form the CPG to decisions in similar but not identical circumstances. The findings and recommendations do not including all acceptable methods of care and do invalidate methods of care that are not included but are reasonably expected to meet the needs of the patient(s). The treatment of surgical site infections can be extremely challenging. The recommendations and consensus statements that follow were generated by isolating of data on individual factors to determine independent effects. Patient specific factors and local resources are paramount in clinical decision making often requiring consideration of multiple factors and concurrently delivering more than one intervention. The ultimate judgment regarding any specific procedure or treatment must be made in light of all circumstances pertinent to an individual patient .

INTENDED USERS

This SR and CPG is intended to be used by orthopaedic surgeons, infectious disease specialists and other care providers that manage orthopaedic surgical site infections. Typically, these care providers SSI have completed accredited training including additional sub-specialty training, gaining an understanding of the issues and nuances inherent to SSI management. Adult primary care physicians, geriatricians, hospital based adult medicine specialists, physical therapists, occupational therapists, nurse practitioners, physician assistants, emergency physicians, and other healthcare professionals who provide respective care for related and concurrent conditions in patients with SSIs in various practice settings may also benefit from the information in the CPG.

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Management of surgical site infection is based on the assumption that decisions are predicated on physician discussion with the patient and/or the patient's qualified heath care advocate about available treatments and procedures applicable to each individual patient. Once the patient and/or their advocate are informed of available therapies and have discussed these options with his/her physician, an informed decision can be made. Clinician input based on experience with conservative management and medical and surgical interventions increases the probability of identifying the most beneficial treatment options for each individual patient.

The guideline is not intended for use as a benefits determination document.

PATIENT POPULATION

This document addresses the management of surgical site infections occurring in patients who have undergone orthopaedic surgery.

INCIDENCE AND PREVALENCE

Surgical site infections occur following a small percentage of surgical procedures. Approximately 1% of patients undergoing orthopaedic procedures develop an infection at the surgical site.[194] For this systematic review, the Centers for Disease Control and Prevention (CDC) definitions of superficial, deep and organ space surgical site infection were used.[194] In 2011, the CDC estimated that there were 157,500 surgical site infections from all inpatient surgeries performed in the United States.[194]

ETIOLOGY

Surgical site infections are the result of disease-causing bacteria or fungi which enter the body through a surgical wound.[M4] Since the definition of "surgical site infection" can be interpreted differently, we used the standard definition from the Centers for Disease Control described in the previous paragraph. The CDC describes a surgical site infection as "… an infection that occurs after surgery in the part of the body where the surgery took place. Surgical site infections can sometimes be superficial infections involving the skin only. Other surgical site infections are more serious and can involve tissues under the skin, organs, or implanted material." During the time when the reviewed studies were being performed the definition of a SSI change from infections occurring during the 12 months following the procedure to infections that occurred within 3 months of the procedure. This does not represent a change in fundamental condition that was studied or lead to a change in the conclusions drawn from the data; more that the small proportion of cases that occur after the first 3 months does not meaningfully change the analysis but is associated with onerous logistics and an unjustified expense. The findings were not stratified reports that include or do not include cases from 3 -12 months post op.

RISK FACTORS

Possible risk factors for surgical site infections are complex. During the design phase it was recognized that risk factors effecting occurrence and severity of SSI have implications for management. To that end risk factors were included in the systematic review and development of the CPGs, but, this work is not a comprehensive review or analysis of factors that occur preoperatively, or are unrelated to management, including risks factors. Please refer to the recommendations on prognostic indicators for risk of surgical site infections for further information.

POTENTIAL BENEFITS, HARMS, AND CONTRAINDICATIONS

Most treatments are associated with some known risks, especially invasive and operative treatments. Contraindications vary widely based on the treatment and the patient. A particular concern when managing surgical site infections is the potential for the underlying orthopaedic treatment to be compromised resulting in increased morbidity or decreased function compared to initial expectations. Additional factors may affect the physician's choice of treatment, including co-morbidities such as low bone mass or arthropathy in other joints. Provider judgement based on clinical experience increases the

probability of identifying the treatment options for each individual patient that have the most favorable risk/benefit expectation.

FUTURE RESEARCH

Consideration for future research is provided for each recommendation within this document are based on the work groups clinical experience and perceived need for better guiding data.

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METHODS

The methods used to perform this systematic review were employed to minimize bias and enhance transparency in the selection, appraisal, and analysis of the available evidence. These processes are vital to the development of reliable, transparent, and accurate clinical recommendations for management of surgical site infections. To view the full AAOS clinical practice guideline methodology please visit the SSI SR eAppendix or www.aaos.org/cpg.

This systematic literature review evaluates the effectiveness of treatments for management of surgical site infections. The AAOS approach incorporates practicing physicians (clinical experts) and methodologists who are free of potential conflicts of interest relevant to the topic under study, as recommended by systematic literature review development experts.[1]

This systematic literature review was prepared by the AAOS Management of Surgical Site Infections systematic literature review physician development group (clinical experts) with the assistance of the AAOS Quality and Value (QV) Unit in the Department of Research, Quality and Scientific Affairs (methodologists) . To develop this systematic literature review , the systematic literature review development group held an introductory meeting on September 25, 2015 to establish the scope of the systematic literature review. As the physician experts, the systematic literature review development group defined the scope of the systematic literature review by creating PICO Questions (i.e. population, intervention, comparison, and outcome) that directed the literature search. The AAOS Medical Librarian created and executed the search (see SSI SR eAppendix 1 for search strategy).

DEFINITION OF "SURGICAL SITE INFECTION"

The Centers for Disease Control's (CDC) most current criteria for defining surgical site infection was used for this review (i.e. "date of event for infection occurs within 30 days after any NHSN operative procedure, where day 1=the procedure date"); however, this definition was updated from previous CDC criteria defining surgical site infections as occurring within one year. Because many of the studies evaluated within this review we published using the previous (one year) definition of surgical site infections, it should be noted that the findings used to create recommendations within this document incorporate both the current and past CDC criteria for defining surgical site infections.

BEST EVIDENCE SYNTHESIS

We included only the best available evidence for any given outcome addressing a recommendation. Accordingly, we first included the highest quality evidence for any given outcome if it was available. In the absence of two or more occurrences of an outcome at this quality, we considered outcomes of the next lowest quality until at least two or more occurrences of an outcome had been acquired. For example, if there were two 'moderate' quality occurrences of an outcome that addressed a recommendation, we did not include 'low' quality occurrences of this outcome. A summary of excluded articles can be viewed in the SSI SR eAppendix 1`. All of the detailed data for each recommendation can be found via the SSI SR eAppendix 2.

LITERATURE SEARCHES

The medical librarian conducted a comprehensive search of PubMed, Embase, and the Cochrane Central Register of Controlled Trials based on key terms and concepts from the systematic literature review development group's preliminary recommendations. Bibliographies of relevant systematic reviews were hand searched for additional references. All databases were last searched on March 13, 2017 with limits for publication dates from 1966-2017 and English language.

DEFINING THE STRENGTH OF THE RECOMMENDATIONS

Judging the strength of evidence is only a stepping stone towards arriving at the strength of a systematic literature review recommendation. The strength of recommendation (Table 1) also takes into account the quality, quantity, and the trade-off between the benefits and harms of a treatment, the magnitude of a treatment's effect, and whether there is data on critical outcomes. Table 2 addresses how to interpret the strength of each recommendation.

VOTING ON THE RECOMMENDATIONS

The recommendations and their strength were voted on by the guideline development group members during the final meeting. If disagreement between the guideline development group occurred, there was further discussion to see whether the disagreement(s) could be resolved. Recommendations were approved and adopted in instances where a simple majority (60%) of the guideline development group voted to approve; however, the guideline development group had consensus (100% approval) when voting on every recommendation for this guideline.

INTERPRETING THE STRENGTH OF EVIDENCE

Table I. Strength of Recommendation Descriptions

Strength	Overall Strength of Evidence	Description of Evidence Quality	Strength Visual
Strong	Strong	Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.	
Moderate	Moderate	Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.	
Limited	Low or Conflicting Evidence	Evidence from two or more "Low" quality studies with consistent findings **or** evidence from a single "Moderate" quality study recommending for against the intervention or diagnostic or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.	
Consensus*	No Evidence	There is no supporting evidence. In the absence of reliable evidence, the systematic literature review development group is making a recommendation based on their clinical opinion. Consensus statements are published in a separate, complimentary document.	

Table II. Clinical Applicability: Interpreting the Strength of a Recommendation

Strength of Recommendation	Patient Counseling (Time)	Decision Aids	Impact of Future Research
Strong	Least	Least Important, unless the evidence supports no difference between two alternative interventions	Not likely to change
Moderate	Less	Less Important	Less likely to change
Limited	More	Important	Change possible/anticipated
Consensus	Most	Most Important	Impact unknown

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PEER REVIEW
Following the final meeting, the systematic literature review draft undergoes a two week peer review for additional input from external content experts. Written comments are provided on the structured review form (SSI SR Peer Review and Public Comment eReport). All peer reviewers are required to disclose their conflicts of interest.

PUBLIC COMMENTARY
After modifying the draft in response to peer review, the systematic literature review was subjected to a two week period of "Public Commentary." Commentators consist of members of the AAOS Board of Directors (BOD), members of the Council on Research and Quality (CORQ), members of the Board of Councilors (BOC), and members of the Board of Specialty Societies (BOS). The systematic literature review is automatically forwarded to the AAOS BOD and CORQ so that they may review it and provide comment prior to being asked to approve the document. Members of the BOC and BOS are solicited for interest. If they request to see the document, it is forwarded to them for comment. Based on these bodies, over 200 commentators have the opportunity to provide input into this systematic literature review. To view comments, visit the SSI SR Peer Review and Public Comment View background material via the SSI SR Peer review/Public Comment eReport.

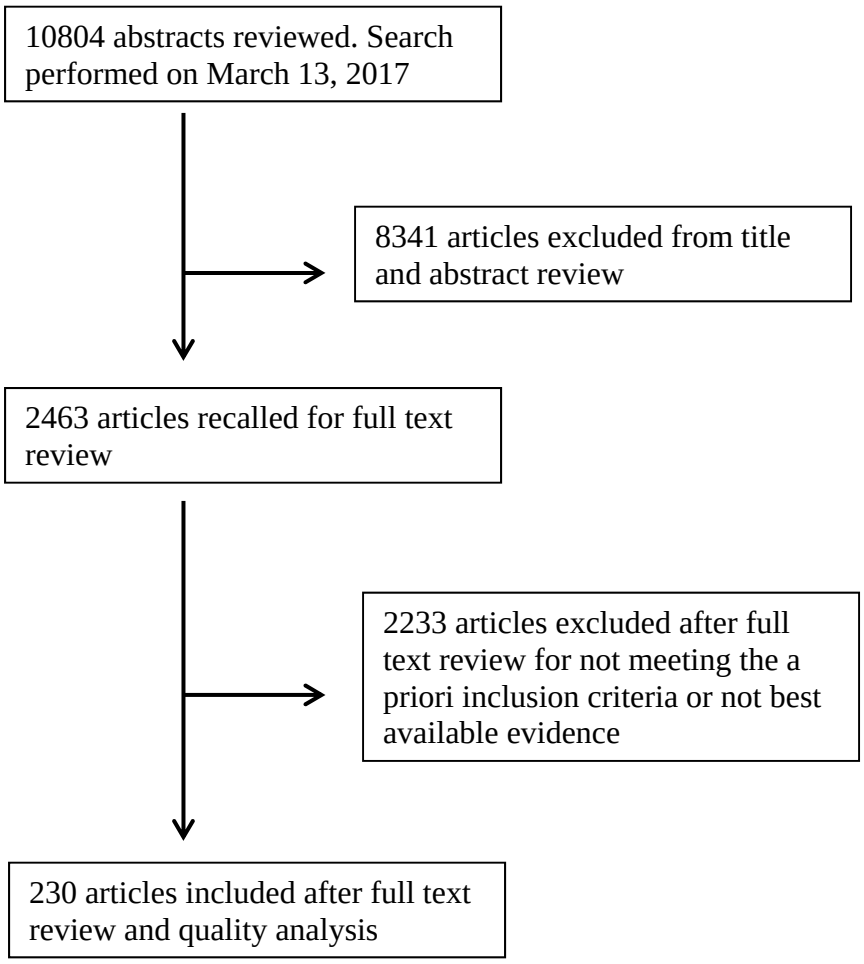
THE AAOS SYSTEMATIC LITERATURE REVIEW APPROVAL PROCESS
This final systematic literature review draft must be approved by the AAOS Committee on Evidence Based Quality and Value Committee, the AAOS Council on Research and Quality, and the AAOS Board of Directors. These decision-making bodies are described in the SSI SR eAppendix. Their charge is to approve or reject its publication by majority vote.

REVISION PLANS
This systematic literature review represents a cross-sectional view of current treatment and may become outdated as new evidence becomes available. This systematic literature review will be revised in accordance with new evidence, changing practice, rapidly emerging treatment options, and new technology. This systematic literature review will be updated or withdrawn in five years in accordance with the standards of the National Guidelines Clearinghouse.

SYSTEMATIC LITERATURE REVIEW DISSEMINATION PLANS
The primary purpose of the present document is to provide interested readers with full documentation of the best available evidence for various procedures associated with the topic of this review. Publication of most systematic literature reviews is announced by an Academy press release, articles authored by the systematic literature review development group and published in the Journal of the American Academy of Orthopaedic Surgeons, and articles published in AAOS *Now*. Most systematic literature reviews are also distributed at the AAOS Annual Meeting in various venues such as on Academy Row and at Committee Scientific Exhibits.

Selected systematic literature reviews are disseminated by webinar, an Online Module for the Orthopaedic Knowledge Online website, Radio Media Tours, Media Briefings, and by distributing them at relevant Continuing Medical Education (CME) courses and at the AAOS Resource Center.

STUDY ATTRITION FLOWCHART



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RECOMMENDATIONS

MEDICAL IMAGING

Limited evidence supports the use of medical imaging in the diagnostic evaluation of patients with a suspected organ/space (i.e. bone, joint, and implant) surgical site infection.

Strength of Recommendation: Limited ★★☆☆

*Description: Evidence from two or more "Low" quality studies with consistent findings **or** evidence from a single "Moderate" quality study recommending for or against the intervention or diagnostic test or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.*

Radiography

There was one moderate quality study (Bernard 2004) evaluating the use of radiography for patients with suspected hip and knee prosthesis infection. This study showed poor agreement of radiography with the confirmed infections as both a "rule in" test and a "rule out" test. However Radiography is widely available and inexpensive relative to other imaging modalities, and the consensus of the workgroup is that radiographs be considered as the initial imaging exam for suspected cases of bone and/or implant infection interpreted in combination by a provider with skill and experience in interpretation of musculoskeletal radiographs to assess any and all radiographic features of infection, or other causes of the patient's symptoms, without commenting on or recommending any single finding or combination of findings.

Radiolabeled Leukocyte Imaging

There were five high quality (Scher 2000, Simonsen 2007, Rand 1990, Pelosi 2004, Joseph 2001) and 10 moderate quality (Pons 1999, Glithero 1993, Kim 2014, Love 2004, Segura 2004, Chik 1996, El Espera 2004, Bernard 2004, Fuster 2011, Wolf 2003) studies evaluating the use of radiolabeled leukocyte imaging (with Indium-111 or Tc-99m hexamethylpropyleneamine oxine) for patients with suspected surgical site infections, predominantly patients with suspected hip and knee prosthesis infection. The duration of time between the initial surgery and the performance of the scan was either unclear or greater than 1 year, on average, for most of these studies. These studies showed inconsistent agreement of radiolabeled leukocyte imaging with the confirmed infections as "rule in" and "rule out" tests. For example, two high quality studies (Scher 2000, Simonsen 2007) showed moderate-strong agreement of radiolabeled leukocyte imaging with the reference standard as a "rule in" test, and weak-moderate agreement as a "rule out" test, for patients with suspected infected hip prostheses. By contrast, two high quality studies (Rand 1990, Scher 2000) showed only weak-moderate agreement of radiolabeled leukocyte imaging with the confirmed infections as a "rule in" test for patients with suspected infected knee prostheses. Stronger agreement with the reference test might be possible in combination with single photon emission computed tomography (Kim 2014) or Tc-99m sulfur colloid bone marrow scintigraphy (Love 2004). The consensus of the workgroup is that radiolabeled leukocyte imaging can be useful as a diagnostic tool (i.e., among other tests) as a "rule in" or "rule out" test for prosthetic joint infection, but its routine use for diagnosis of such infection is not justified, as there may be difficulties diagnosing insidious infections or differentiating infection from aseptic loosening. When radiolabeled leukocyte imaging is performed, the addition of bone marrow scintigraphy can help increase specificity.

Tc-99m-Diphosphonate Skeletal Scintigraphy ("Bone Scan")

There were three moderate quality studies (Nagoya 2008, Battaglia 2011 and Segura 2004) evaluating the use of skeletal scintigraphy for patients with suspected hip and knee prosthesis infection occurring, on

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average, greater than one year following surgery. Although one study (Segura 2004) showed strong agreement of two-phase (blood pool and delayed imaging) skeletal scintigraphy with the confirmed infections as a "rule out" test, other studies showed moderate (Nagoya 2008, 3-phase scintigraphy) or weak (Battaglia 2011, unknown number of phases) agreement. Two of the studies (Battaglia 2011, Segura 2004) showed poor agreement of skeletal scintigraphy with the confirmed infections as a "rule in" test, while Nagoya 2008 showed moderate agreement of (3-phase scintigraphy) as a "rule in" test. Skeletal scintigraphy can be useful as a diagnostic tool (i.e., among other tests) as a "rule out" test for delayed (>1 year) prosthetic joint infection if radiolabeled leukocyte imaging is not available, but its role in the diagnosis of such infection is limited.

Positron Emission Tomography (PET) Imaging

There were four high quality (Chacko 2002, Chryssikos 2008, Aksoy 2014, DeWinter 2003) and 3 moderate quality (Kobayashi 2011, Love 2004, Wenter 2015, 2017) studies evaluating the use of F-18 fluorodeoxyglucose (FDG) PET imaging for patients with suspected surgical site infections, with most patients having suspected infection of orthopaedic implants including joint prostheses. The duration of time between the initial surgery and the performance of the scan was either unclear or greater than one year, on average, for most of these studies. These studies showed inconsistent agreement of PET imaging with the confirmed infections as a "rule in" test. For example, two high quality studies (Chacko 2002, Chryssikos 2008) showed strong agreement of FDG-PET imaging with the confirmed infections as a "rule in" test for prosthetic hip joint infection when uptake at the prosthesis-bone interface was used as the criterion for infection. However, another high-quality study (Aksoy 2014) showed that 39/39 hip and knee prostheses with aseptic loosening also showed increased FDG uptake, resulting in poor agreement with the confirmed infections as a "rule in" test for infection. A couple of high quality studies (Chacko 2002, DeWinter 2003) suggest that FDG-PET imaging may be useful as a "rule out" test, showing strong agreement with the confirmed infections; however, other studies show inconsistent results. Better agreement with the reference test might be possible in combination with computed tomography (Wenter 2015). The presence of metallic implants may also affect the diagnostic ability of FDG PET; one high quality study (DeWinter 2003) evaluating the use of FDG PET imaging for patients with suspected surgical site infections of the spine showed weak agreement of PET with the confirmed infections as a "rule in" test when metallic implants were present, but strong agreement as a "rule in" test when implants were not present. Although FDG-PET can be useful as a diagnostic tool (i.e., among other tests) as a "rule in" or "rule out" test for infection, its availability, expense, and current issues with reimbursement are limiting factors, and its routine use is not justified in this setting.

Cross-Sectional Imaging (Magnetic Resonance Imaging, Computed Tomography, Ultrasonography)

There is a lack of data regarding the use of cross-sectional imaging for the diagnosis of orthopaedic surgical site infection. Two moderate quality studies (Li 2016, Plodkowski 2013) evaluating the use of magnetic resonance imaging (MRI) for patients with suspected knee prosthesis infection showed moderate-strong agreement of MRI with the confirmed infections as a "rule in" test, but poor-moderate agreement as a "rule out" test. However, artifacts caused by metallic implants can be significant and limit detection of adjacent bone and soft tissue infection on MRI as well as on computed tomography (CT). Cross-sectional imaging can potentially be useful as a diagnostic tool in certain patients with suspected surgical site infection (e.g., to identify soft-tissue fluid collections) or to guide aspiration/biopsy procedures in such patients, but the potential value of a given imaging exam should be considered on a case-by-case basis.

Possible Harms of Implementation

There are no known harms of implementation of this recommendation beyond those risks associated with the individual imaging procedures, e.g., potential adverse effects of ionizing radiation, intravenous injection of contrast materials and radiopharmaceuticals, metallic implants (MRI), etc.

Future Research

Most of the literature exploring the imaging of suspected postoperative infections pertains to patients with prosthetic joints, with cohorts of patients whose imaging examinations occurred months to years following surgery. Furthermore, there is a lack of data regarding the sensitivity and specificity of imaging tests for the diagnosis of infections during the first 90 days following surgery as well as surgical site infections not associated with implants. Future research exploring the diagnostic value of imaging for surgical site infections in patients with or without orthopaedic implants in the early (<90 days) postoperative period is necessary. This could include comparative studies between various imaging modalities which may further clarify the utility of each modality for the diagnosis of suspected surgical site infection

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CULTURES

Strong evidence supports that synovial fluid and tissue cultures are strong rule-in tests for the diagnosis of infection; negative synovial fluid and tissue cultures do not reliably exclude infection.

Strength of Recommendation: Strong ★★★★

Description: Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

RATIONALE

Ten high quality studies were identified that addressed the role of culture in the diagnosis of surgical site infection; notably only two of the studies (Holinka, Puig-Verdie) included patients with infections involving orthopaedic sites other than hip or knee arthroplasties.

SYNOVIAL FLUID CULTURES

Three high quality studies (Gallo, Tomas, Spangehl) evaluated the yield of synovial fluid cultures in the diagnosis of prosthetic joint infection. Two of the studies found strong evidence to support fluid culture in the diagnosis of PJI (Tomas, Spangehl) while one found moderate evidence in support (Gallo).

INTRAOPERATIVE TISSUE CULTURES

Seven high quality studies evaluated the yield of intra-operative tissue cultures in the diagnosis of surgical site infection (Aggarwal, Holinka, Hughes, Panousis, Puig-Verdie, Spangehl, Trampuz). Of these, six of the seven studies revealed strong evidence in support of tissue culture to rule in the diagnosis of infection; one found the evidence to be moderate (Holinka). Additionally, the method by which the organism was grown was relevant. In these seven studies, there was variability in the performance of tissue culture in excluding infection. One high quality study evaluated the value of positive culture only from enrichment broth (Smith). Broth-only positive cultures showed poor correlation as a rule-in or rule-out test for infection. Two high-quality studies evaluated the performance of tissue cultures compared with swab cultures (Aggarwal, Spangehl). Both demonstrated better accuracy of tissue cultures over swab cultures.

NUMBER OF INTRAOPERATIVE CULTURES

Multiple tissue cultures should be collected to improve the accuracy of infection diagnosis. One moderate quality study (Atkins) quantified the number of samples needed to confirm the diagnosis of infection. A single positive culture for an organism of limited virulence was shown to have poor predictive value as a rule-in test. Two distinct positive cultures for the same organism provided strong evidence of periprosthetic infection.

DURATION OF CULTURE INCUBATION

One high quality (Schafer) and one moderate quality (Butler-Wu) study reviewed the duration of culture incubation for chronic periprosthetic infection. Both studies demonstrated improved yield when both aerobic and anaerobic cultures were incubated for 14 days.

PRIOR ANTIBIOTIC EXPOSURE

One high quality study evaluated the effect of prior antibiotic therapy on the yield of sonicate and tissue culture. The yield of culture was reduced when antibiotic therapy was administered within 14 days of culture collection.

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POSSIBLE HARMS OF IMPLEMENTATION:

In the setting of low suspicion for infection, there is greater likelihood that a single positive culture will represent a false-positive and may further confound management decisions. Further, in the setting of low clinical suspicion for infection, synovial fluid aspiration may unnecessarily expose the patient to risk. External swabbing of wound drainage may lead to false positive cultures that may lead to unnecessary treatment.

FUTURE RESEARCH

The majority of studies on the role of culture in the diagnosis of surgical site infection stemmed from studies in periprosthetic infection. Development of optimal culture protocols for surgical site infections other than periprosthetic joint infections are needed. Future research directions may also include advanced non-culture based diagnostic modalities including PCR and next generation sequencing.

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C-REACTIVE PROTEIN

Strong evidence supports that C-reactive Protein is a strong rule-in and rule-out marker for patients with suspected surgical site infections.

Strength of Recommendation: Strong ★★★★

Description: Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Multiple high-quality studies and meta-analysis of the study data support the use of C-reactive protein in the diagnosis of surgical site infection (Bottner et al 2007, Glehr et al 2013, Cipriano et al 2012, Jacovides et al 2011). Several moderate quality studies (Yi et al 2015, Piper et al 2009, 2010, Bedair et al 2011) also support its use. It was found to be both sensitive and specific in detecting periprosthetic infection and served as an accurate screening tool, with a positive or negative value demonstrating the likelihood of the presence or absence of infection. Studies vary with respect to the timing and thresholds used to diagnose infection. Both Yi et al 2015 and Bedair et al 2011 confirmed its utility during the early postoperative period. Despite this variation, it has proven its accuracy across investigations. While cutoff values at which an infection is diagnosed vary between studies, and based on time postoperatively it has been shown to be a superior screening test relative to other serological studies.

Possible Harms of Implementation

There is no risk with implementation of this test. However, elevated CRP can be misleading in cases of chronic inflammatory conditions, neoplasms, metabolic syndrome that can cause its elevation and therefore should be monitored over the entire course of treatment.

Future Research

Much of the work on inflammatory markers has been focused upon total joint arthroplasty. Future research should focus on identifying more accurate inflammatory markers, and distinguishing a standardized set of criteria and thresholds to aid in the diagnosis of surgical site infection not only as it pertains to PJI but in other cases of SSI.

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ERYTHROCYTE SEDIMENTATION RATE

Limited strength evidence does not support the use of ESR, alone, to rule in and rule out surgical site infections due to conflicting data.

Strength of Recommendation: Limited 

*Description: Evidence from two or more "Low" quality studies with consistent findings **or** evidence from a single "Moderate" quality study recommending for or against the intervention or diagnostic test or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.*

Multiple high-quality studies (Bottner et al 2007, Cipriano et al 2012, Panousis et al 2005) have demonstrated moderate to weak ability of ESR as a solitary test to diagnose or exclude surgical site infection. It is felt to be too variable with respect to time from surgery and in the presence of other confounding factors (such as inflammatory arthropathy) to be considered an accurate tool in diagnosis alone but may be considered as a tool to be used in conjunction with other tests.

Possible Harms of Implementation
There is no risk with implementation of this test/recommendation, however ESR should rarely be considered in isolation. ESR should be used in combination with other tests to mitigate the risk of incorrect diagnoses.

Future Research
ESR is of limited utility in the diagnosis of SSI as an isolated test. Future investigations will likely examine the use of ESR in combination with other diagnostic markers.

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CLINICAL EXAM FOR THE DIAGNOSIS OF SURGICAL SITE INFECTIONS

Moderate strength evidence supports that clinical exam (i.e. pain, drainage, fever) is a moderate to strong rule-in test (i.e. high probability of presence of infection, if test is positive) for patients with suspected surgical site infections, but a weak rule-out test.

Strength of Recommendation: Moderate 

Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.

Patients with suspected surgical site infections should be assessed by a history and physical examination. Specific data were available for a structured history, presence of fever, and persistent wound drainage. One study of moderate evidence by Pons 1999 used a structured interview to evaluate 80 patients undergoing revision total hip arthroplasty of whom 16 patients had proven infection by histology and microbiology culture. A positive clinical examination was the presence of one of the following: current painful joint, history of chronic joint pain; or a history of wound drainage or fever lasting greater than 48 hours in the first month after primary surgery. A positive history had a sensitivity of 0.625 and specificity of 0.98.

One moderate strength study by Bernard 2004 evaluated the presence of fever and persistent drainage against the confirmed infections of positive culture in 230 patients undergoing revision joint surgery. Fever had a sensitivity of 0.53 and specificity of 0.90, and persistent drainage had a sensitivity of 0.53 and specificity of 0.90.

Possible Harms of Implementation

There are no known harms associated with implementing this recommendation. It should be noted that the absence of pain after treatment does not assure the absence of infection.

Future Research

Clinical factors that can be determined from history and physical exam that identify patients at risk for surgical site need further investigation. The possible linkage of persistent fevers and the wound drainage to surgical site infections are needed. Characterization and development of protocols to manage early poorly healing or inflamed wounds are needed.

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STRONG EVIDENCE OF FACTORS ASSOCIATED WITH INCREASED RISK OF SSI

Strong evidence supports that the following factors are associated with an increased risk of infection:

- **Anemia**
- **Duration of Hospital Stay**
- **Immunosuppressive Medications**
- **History of Alcohol Abuse**
- **Obesity**
- **Depression**
- **History of Congestive Heart Failure**
- **Dementia**
- **HIV/AIDS**

Strength of Recommendation: Strong 

Description: Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Anemia

There were eight high quality studies on the association of Anemia with the risk of SSI. Of these, five revealed an association between anemia and SSI. Four studies reviewed the risk of PJI and the 5th study reviewed the risk of infection and cervical spine fusion. Determinations were based on regression analyses of large data bases. Greenky et al 2012 identified the significant risk of anemia in PJI of development of SSI.

Possible Harms of Implementation

There are no known harms associated with implementing this recommendation

Future Research

Continue studies comparing preoperative anemia with orthopaedic procedures is warranted to identify both the level of anemia that leads to an increased SSI risk and how different types of anemia can influence SSI risk.

Duration of Hospital Stay

There were 11 high quality studies that examined the association between the length of hospital stay and the risk of SSI. Of these, seven revealed an association between increased length of stay and the risk of SSI. The studies were a range of multi-variant analysis and regression analysis. Three studies revealed that prolonged preoperative inpatient stays were related to increased risk of infection. Four studies revealed that prolonged post op hospitalization correlated with an increased risk of SSI. Longer hospital stays, including both pre-op and post-op stays correlated with increasing risk of SSI development.

Possible Harms of Implementation

Premature discharge of patients without identifying unstable medical conditions is a risk of shortened hospital stay.

Future Research

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Attempts at identifying the optimal length of stay should be continued. Identify optimal discharge pathways for each individual patient. The correlation with early discharge and rates of readmission needs to be assessed. Understand the relative contribution of comorbidity-severity related to the duration of hospital stay.

Immunosuppressive Medication

Ten high quality studies were reviewed that looked at the effects of immunosuppressive agents. Of these, seven revealed a strong correlation between the use of immunosuppressive medications and an increased risk of SSI. These studies reviewed the effects of these medications on the risk of SSI associated with total joint replacement, spine surgery and ACL reconstruction. Momohara 2011 identified specifically that infliximab and etanercept combined with prolonged disease duration were associated with increased SSI risk. Giles 2006 identified increased risks of SSI associated with taking Tumor Necrosis Factor medications

Possible Harms of Implementation

There are no known harms associated with implementing this recommendation. Stopping the administration of immunosuppressive drugs however may increase the risk of developing a flare up of the underlying inflammatory disease. The American College of Rheumatology systematic literature review on perioperative management of antirheumatic medications provides further guidance on how to effectively administer immunosuppressive medications to patients undergoing surgery.

Future Research

The list of immunosuppressive drugs is expanding rapidly and the research on the effects of these newer drugs is needed. Also, additional information about dosing, discontinuing medication before surgery and additional orthopaedic procedures that might be impacted are also needed. Future trials should examine optimal time for discontinuing immunosuppressive medications prior to surgery.

Alcohol abuse

Five high quality articles were reviewed. Three revealed a strong correlation between alcohol abuse and the risk of SSI. The articles used multi-variant analysis and looked a range of orthopaedic procedures and the effect of alcohol abuse on the risk of SSI on these procedures. Large multivariate studies from Cavanaugh 2015, Grammatico 2015 and Jain 2015, surveying thousands of patients, consistently show increased risks associated with increased alcohol consumption.

Possible Harms of Implementation

Alcohol withdrawal is a risk.

Future Research

Further research is needed on assessment tools to assess the relation of alcohol consumption and surgical risk.

Obesity

Fourteen high quality studies showed a correlation between obesity and the risk of SSI. These studies used multivariant analysis showing that increasing BMI correlated strongly with the risk of post op infection. All of the studies showed significantly increased risk of SSI that correlate well with increased BMI. Several studies identified additional risks associated with increased BMI over 40. These risks include cardiac, pulmonary and systemic complications in additional to the increased SSI risks.

Possible Harms of Implementation

There are no known harms associated with implementing this recommendation. Although there is an association between obesity and increased risk of postop SSIs, the risk of denying care to this patient population could have significant implications to the socioeconomic burden and quality of life of this population.

Future Research
Future research is needed to assess the role of nutrition in the modification of obesity and the effects of high BMI and BMI-associated comorbidities on the risk surgical site infections.

Depression
Four high quality studies confirmed a correlation between depression and the risk of SSI. All four studies used regression analysis. In each of the multivariate studies a correlation between clinically detected depression and increased risks of surgical site infection was identified.

Possible Harms of Implementation
The risks are unknown.

Future Research
Needed to see if treatment of depression alters the association between severity of depression and the risk of wound infections. The precise pathophysiology of this correlation is unknown.

Congestive Heart Failure
Two high quality studies revealed a strong correlation between the risk of CHF and SSI. These studies were all multi-variant regression analysis studies. Patients with CHF also have a higher risk of other vascular problems.

Possible Harms of Implementation
There are no known risks to optimizing congestive heart failure prior to surgical intervention.

Future Research
The correlation between adequate control of CHF and the severity of CHF, and the risk of SSI need to be further investigated.

Dementia
Two large high quality studies using regression analysis revealed a strong correlation between Dementia and the risk of SSI in geriatric fractures patients. Dementia is an independent risk factor for occurrence of a surgical site infection

Possible Harms of Implementation
There are no known harms associated with implementing this recommendation

Future Research
Future research should focus on preoperative assessment of patients with dementia.

HIV/AIDS
Four high quality studies revealed a high correlation between the diagnosis of HIV/AIDs and the risks of SSI. There was a strong correlation between the diagnosis of HIV/AIDs and the risk of infection. Boylan revealed an increased risk of SSI of 17%.

Possible Harms of Implementation

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Patients with HIV infection should receive antiretroviral therapy, and have control of opportunistic infections, and immune reconstitution, when possible, prior to any orthopaedic surgery. There are no known harms with implementing this recommendation.

Future Research

Ongoing research in HIV/AIDS infection is needed to optimize surgical care of this patient population.

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MODERATE EVIDENCE OF INCREASED ASSOCIATED RISK OF SSI

Moderate strength evidence supports that patients meeting one or more of the following criteria are at an increased risk of infection after hip and knee arthroplasty:

- **Chronic Kidney Disease**
- **Diabetes (conflicting evidence)**
- **Tobacco Use/Smoking (conflicting evidence)**
- **Malnutrition (conflicting evidence)**

Strength of Recommendation: Moderate 

Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.

Chronic Kidney Disease

The risk of SSI in patients with chronic kidney disease (CKD) correlates positively with the severity of renal disease. Five high quality studies revealed using multivariate analysis and to identify the increased risk of SSI in patients with CKD. The severity of CKD and the description of dialysis and transplant patients were not identifiable within the studies.

Possible Harms of Implementation

There are no known harms associated with implementing this recommendation.

Future Research

Future research should evaluate and correlate the severity of renal disease with precise risk of SSI. Additionally, it should use common terminology for renal disease and stratify by dialysis, transplant, and severity of disease.

Diabetes

26 high quality studies were reviewed. 13 of the studies showed a correlation between diabetes and the risk of SSI. 13 studies showed no correlation between diabetes and the risk of SSI. The strength of the recommendation was classified as "moderate" due to the divergence between the study findings. The impact of quality diabetic control could not be determined on the outcomes of the studies.

Possible Harms of Implementation

Risks include potential over or under-control of blood sugar levels, both preoperatively and postoperatively. See Endocrine society's guidline on control of diabetes in patients preoperatively and postoperatively.

Future Research

Further studies are needed to identify the relationship between the control of diabetes, Hgb A1C, and the risk of post-operative infection.

Tobacco Use

22 high quality studies were reviewed. 9 studies showed an association between tobacco use and increased risk of SSI. 12 studies showed no statistically significant differences between smokers and nonsmokers regarding associated risk of SSI. Many of the studies do not define the amount of tobacco

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used, description of current versus former smokers, or the length of time for use of tobacco. While tobacco use is widely accepted as a risk factor for increasing the risk of SSI, of 22 HQ studies, 9 confirmed the correlation and 12 failed to confirm the correlation, and one showed a negative association with smoking and risk of SSI. This may be due to the definition of magnitude, effect size, heterogeneity of populations between studies.

Possible Harms of Implementation
There are no known harms associated with recommending the cessation of smoking to decrease the risk of SSI. If smoking cessation is not counseled based on limited evidence, that could lead to additional harms to the patient.

Future Research
Research is needed to define the exact correlation between the extent and length of time of tobacco use and the risk of SSI. Determine role of smoking cessation and reducing the risk of SSI. Further study is needed to delineate the duration of smoking cessation and its impact on the occurrence of SSI.

Malnutrition
Malnutrition is a known risk factor for patients undergoing surgical procedures. Patients with malnutrition can suffer from a range of poor outcomes including increased risk of death, sepsis and poor wound healing. Six high quality articles were reviewed. Of these, three articles identified a correlation with increased risk of SSI. Bohl et al 2016 identified significantly increased risks of SSI associated with hypoalbuminemia. Grammatico et al 2015 also showed higher risks of SSI due to malnutrition.

Possible Harms of Implementation
There are no known harms associated with implementing this recommendation.

Future Research
Further research is needed to correlate the severity of malnutrition with the concomitant risk of SSI. Also, research into correcting malnutrition and how long after correction will the risk of SSI be reduced. Better definitions of malnutrition should be established via future research.

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LIMITED EVIDENCE OF INCREASED ASSOCIATED SSI RISK

Limited strength evidence supports that patients meeting one or more of the following criteria are at an increased risk of infection after hip and knee arthroplasty:

- **Cancer**
- **Hypertension (conflicting evidence)**
- **Liver Disease (conflicting evidence)**

Strength of Recommendation: Limited 

*Description: Evidence from two or more "Low" quality studies with consistent findings **or** evidence from a single "Moderate" quality study recommending for or against the intervention or diagnostic test or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.*

Cancer

Two high quality studies showed a correlation between cancer and the risk of SSI. Many of the studies did not specify the type of cancer or the staging of the cancer, which is why this recommendation was downgraded to "limited". Cancer encompasses a wide variety of disorders, tissues and severity.

Possible Harms of Implementation

There are no known harms associated with implementing this recommendation. Failing to coordinate treatment with oncologic care may increase the risk of complications.

Future Research

Specific analysis between the types, severity and metastasis of cancer needs to be performed to identify the exact correlation between the type of cancer and risk of post op infection.

Hypertension

Seven high quality studies were reviewed. Four of the studies showed no correlation between hypertension and risk of surgical site infection. The magnitude of the effect of hypertension on the risk of SSI could not be determined from the included studies.

Possible Harms of Implementation

There are no known harms associated with implementing this recommendation.

Future Research

Further research is needed to further delineate the correlation between SSI and hypertension and the preoperative optimization of hypertension and its effect on SSI need to be established.

Liver Disease

Five studies reviewed the correlation between unspecified liver disease, cirrhosis and SSI. Three of the studies showed a correlation between liver disease and SSI in larger multivariant studies.

Possible Harms of Implementation

There are no known harms associated with implementing this recommendation

Future Research

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Further research is needed to further delineate the correlation between SSI and liver disease and cirrhosis.

ANTIBIOTIC DURATION FOR MANAGEMENT OF SURGICAL SITE INFECTIONS

Moderate evidence supports that, in the setting of retained total joint arthroplasty, antibiotic protocols of 8 weeks do not result in significantly different outcomes when compared to protocols of 3 to 6-month duration.

Strength of Recommendation: Moderate 

Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.

The optimal duration of antibiotic therapy is not known. There was one high quality study (Lora-Tamayo 2016) and two low quality (Puhto 2012, Siqueira 2015) studies that evaluated short term antibiotics vs long term antibiotics in the setting of infected total joint arthroplasties. Both studies showed no significant difference in resolution of infection according to treatment duration.

In the study by Lora-Tamayo 2016, patients with staphylococcal infection were treated with debridement and implant retention and then randomized to either eight weeks or three (hips) or six (knees) months of antibiotic therapy. Resolution of infection was similar in both groups.

In the Puhto 2012 study, which included patients with a variety of microbes, they compared short term (two months total for hips and three months for knees) to their previously used long term (three months for hips and six months for knees). Again, they found no difference in success.

While antibiotic duration may not impact likelihood of cure, long term suppression may reduce the risk of relapse for patients who are not cured (Siqueira 2015). The benefit of chronic antibiotic suppression in this low-quality study was only seen for patients with *Staphylococcus aureus* infection managed with implant retention.

Possible Harms of Implementation
There are no known harms associated with implementation of this recommendation.

Future Research
As the vast majority of research on antibiotic duration currently centers on the topic of periprosthetic joint infections, future research is needed focusing on other orthopaedic settings, like trauma, pediatrics, and spine. Comparative high-quality studies are needed in order to better delineate the term of antibiotics necessary with implant retention. Also needed are further studies comparing term of antibiotics vs chronic suppression. In addition, future research is needed on antibiotic treatment and duration as related to implant removal. Furthermore, not much data exists on microbes other than *Staphylococcus aureus*.

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RIFAMPIN USE FOR MANAGEMENT OF SURGICAL SITE INFECTIONS

Moderate evidence supports that rifampin, as a second antimicrobial, increases the probability of treatment success for staphylococcal infections in the setting of retained orthopaedic implants.

Strength of Recommendation: Moderate 

Very few high quality studies were identified regarding the optimal antibiotic treatment regarding specific microbes. One high quality study (Zimmerli 1998) and one low-quality studies (El Helou 2010) addressed the addition of Rifampin and its effect on infection resolution in the setting of debridement and implant retention.

In the high quality study Zimmerli 1998 examined the role of rifampin in the setting of a retained fracture fixation implants and total joint prostheses with *Staphylococca*l infections. Patients who were randomized to receive rifampin as part of their treatment regimen had a lower risk of treatment failure.

Possible Harms of Implementation
Rifampin should never be used in monotherapy. Rifampin is a drug with many potentially adverse drug interactions; its use is best-directed by infectious disease specialists or in conjunction with a pharmacist. Rifampin is not always well-tolerated.

Future Research
Future research is needed to define optimal abx protocols in areas other than joint replacement and organisms other than staph. Very little data exists on the optimal antibiotic regimen in relation to orthopaedic surgical site infection, especially when considering implants outside of joint replacement; in addition, when considering microbes other than Staphylococcus.

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GUIDELINE DEVELOPMENT GROUP DISCLOSURES

Prior to the development of this systematic literature review, systematic literature review development group members disclose conflicts of interest (COI). They disclose COIs in writing to the American Academy of Orthopaedic Surgeons via a private on-line reporting database and also verbally at the recommendation approval meeting.

Disclosure Items: (n) = Respondent answered 'No' to all items indicating no conflicts. 1 = Royalties from a company or supplier; 2 = Speakers bureau/paid presentations for a company or supplier; 3A = Paid employee for a company or supplier; 3B = Paid consultant for a company or supplier; 3C = Unpaid consultant for a company or supplier; 4 = Stock or stock options in a company or supplier; 5 = Research support from a company or supplier as a PI; 6 = Other financial or material support from a company or supplier; 7 = Royalties, financial or material support from publishers; 8 = Medical/Orthopaedic publications editorial/governing board; 9 = Board member/committee appointments for a society.

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