American College of Rheumatology (ACR) Recommendations: Use of Vaccines in Immunosuppressed Conditions

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Disclosures

The speakers of this presentation have no disclosures to declare.

Objectives

- Identify and apply appropriate resources for immunization recommendations.
- Review and interpret the American College of Rheumatology (ACR) vaccination recommendation in patients with rheumatic and musculoskeletal diseases (RMDs).
- Describe the use of live-attenuated vaccines in patients on immunosuppressive medications in patients with RMDs.
- Assess the relative timing of vaccinations and immunosuppressive medications to maximize immunogenicity.

Terminology Definitions

- Adjuvant: an ingredient used in some vaccines that helps create a stronger immune response.
- Immunogenicity: the ability of a vaccine to elicit an immune response.
- Reactogenicity: typical symptoms after vaccine administration.
- Seroconversion: development of antibodies to a pathogen, elicited by vaccine.
- Seroprotection: an antibody level capable of protecting against infection or disease.
- Titer: numerical value indicating the level of antibody against a particular pathogen.

Rheumatic and Musculoskeletal Diseases (RMDs)

Examples of RMDs Include:

- Arthritis (rheumatic, juvenile, etc.)
- Ankylosing spondylitis
- Lupus
- Gout
- Scleroderma
- Sjogren's syndrome
- Spondyloarthritides
- Systemic sclerosis
- Polymyalgia rheumatica
- Systemic vasculitis
- Osteoarthritis, and many more!

Medications used in RMDs

- **Immunosuppressive** medications:
  - Corticosteroids
  - Methotrexate, leflunomide, azathioprine, cyclophosphamide
  - Calcineurin inhibitors
  - Interleukin inhibitors (IL-1, IL-6R, IL-17, IL-12/23, IL-23)
  - Tumor necrosis factor inhibitors
  - BLyS/BAFF inhibitors
  - B-cell depleting agents
  - T-cell co-stimulation inhibitor
  - Janus kinase inhibitors
  - Interferon-α inhibitor

Medications used in RMDs Continued

- **Non-immunosuppressive** medications:
  - Hydroxychloroquine
  - Sulfasalazine
  - Apremilast
  - Intravenous immune globulin (IVIG)

RMD Population Considerations

- Immunosuppressive medications place patients at higher risk of vaccine-preventable infections and serious complications.
- Safety of vaccines and immunogenicity may differ in patients with RMDs compared to the general population.
- Patients may benefit from modified vaccine indications and/or adjustments to vaccination or medication schedules.

Current Resources For Immunization Practices

- Centers for Disease Control and Prevention (CDC)
- Advisory Committee on Immunization Practices (ACIP)
- Epidemiology and Prevention of Vaccine-Preventable Diseases: The Pink Book

Purpose of Guidelines

- Provide evidence-based recommendations on the use of vaccinations in patients with RMD.
- Explain the expanded indications for certain vaccines.
- Illustrate safe approaches to live attenuated vaccines use in immunocompromised patients.

Clinical Decision-Making Considerations

- ACR guidelines are complementary to recommendations made by the Advisory Committee on Immunization Practice (ACIP).
- Application of recommendations should consider patients' individual risk factors for vaccine-preventable illnesses and disease flares.
- Shared decision-making with patients is encouraged in clinical settings.

Role of Pharmacists

As frontline healthcare workers, pharmacists are instrumental in providing patients with pertinent clinical information to help make informed choices regarding vaccinations.

Guideline Methodology

Guidelines Methodology

Definitions:
Strong: panel is very confident that the benefits of an intervention clearly outweighs the harms.
Conditional: Uncertainty regarding the balance of benefits and harms.

Non-Live Vaccination Considerations

Influenza Vaccination

Influenza Vaccination

High-dose or adjuvanted influenza vaccination is ***conditionally recommended*** over regular-dose influenza vaccination for:

- Patients with RMD age ≥65 years.
- Patients with RMD age >18 years and <65 years who are taking immunosuppressive medication.

Per ACIP, immunocompromised patients should receive an age-appropriate influenza vaccination and live influenza vaccines should not be used.

Influenza Vaccination

- Younger patients with rheumatoid arthritis were more likely to develop antibodies after receiving high-dose vaccinations compared to standard-dose.
- There are no studies regarding the use of adjuvanted influenza vaccinations in RMD patients <65 years.
- Generally, no safety issues have occurred with adjuvants.
- If high dose or adjuvanted vaccine is unavailable:
  - Any flu vaccine is preferred over no vaccine.
  - Flu vaccine today is preferred over vaccine delay.

Influenza Vaccination

Seasonal influenza vaccination should be administered even if:

- Active disease
- Rituximab use
- High-dose glucocorticoids use

Influenza Vaccination and High-Dose Glucocorticoids

For patients taking the equivalent of:
Prednisone ≤10mg daily: any non-live vaccinations is ***strongly* recommended.**
Prednisone >10mg but <20 mg daily: any non-live attenuated vaccinations is ***conditionally* recommended.**
Prednisone ≥20mg daily: influenza vaccination is ***conditionally* recommended.**
Deferring non-live attenuated vaccinations, other than influenza vaccination, until glucocorticoids are tapered to the equivalent of prednisone <20mg daily is ***conditionally* recommended.**

ACIP recommends following IDSA guidelines: annual vaccination with non-live influenza vaccinations is recommended.

Influenza Vaccination and High-Dose Glucocorticoids

- Studies have demonstrated that prednisone doses ≥10mg daily had an attenuated immune response compared to doses <10mg daily.
- Several research studies defined prednisone doses ≥20mg daily as high-dose glucocorticoids, and these doses also attenuated immune response to influenza vaccinations.
- The impact of high-dose glucocorticoids on other vaccines is unknown.

Influenza Vaccination and Methotrexate (MTX)

Holding methotrexate (MTX) for 2 weeks after influenza vaccination is ***conditionally*** **recommended**, if disease activity allows.

ACIP recommends following IDSA guidelines: annual vaccination with non-live influenza vaccinations is recommended. No recommendations are made for holding MTX.

Influenza Vaccination and Methotrexate

- MTX has shown to significantly decrease the immune response of influenza vaccine.
- Holding MTX around the time of influenza vaccination had demonstrated improved immunogenicity in randomized control trials.
- Similar results were found when holding MTX for COVID 19 vaccinations.
- Holding MTX for more than 2 weeks may increase flare risk and should be considered prior to recommendation.

Influenza Vaccination and Rituximab

Administration of influenza vaccine on schedule is ***conditionally recommended*** rather than deferring vaccination until next rituximab administration is due.

ACIP recommends waiting at least 6 months after therapy before being vaccinated with non-live vaccines, except for seasonal influenza vaccine.

Non-live Vaccinations and Rituximab

Deferring non–live vaccinations until the next rituximab administration is due (i.e. 6 months after the last rituximab dose) and *delaying* rituximab for 2 weeks after vaccination is ***conditionally* recommended.**

ACIP recommends patients on anti-B cell therapy should wait at least 6 months after therapy before being vaccinated with non-live vaccines.

Influenza Vaccination and Other Medications

Continuing immunosuppressive medications, other than MTX, around the time of influenza vaccination, as well as other non-influenza non-live attenuated vaccinations, is ***conditionally* recommended**.

ACIP recommends following IDSA guidelines: vaccines should be administered prior to planned immunosuppression if feasible. There are no specific recommendations for patients currently established on immunosuppressive therapy.

Influenza Vaccination and Other Medications

- TNF inhibitors had demonstrated similar immunogenicity with influenza vaccination in patients treated with placebo in clinical trials.
- No other studies were identified that addressed holding medications in the setting of other vaccines besides influenza.

Pneumococcal Vaccination

Pneumococcal Vaccination

Patients aged <65 who are on immunosuppressive medication, pneumococcal vaccination is ***strongly* recommended.**

ACIP recommends pneumococcal vaccination to individuals ages >18 for those on immunosuppressive medication.

A variety of schedules are recommended depending on the patient's history of pneumococcal vaccination. Refer to the CDC for most up to date recommendations based on each individual patient.

Herpes Zoster Vaccination

Herpes Zoster Vaccination

Recommendant VZV (Shingrix) is ***strongly*** **recommended** in patients with RMD aged >18 years who are taking immunosuppressive medication.

Per ACIP, recommendant VZV vaccination is recommended for individuals >18 years and < 50 years of age who are immunocompromised, along with the general public age ≥50 years.

Herpes Zoster Vaccination

- Patients with RMDs are at higher risk of zoster than older adults for whom vaccination has been recommended.
- There are no research studies addressing VZV vaccination in patients with RMDs below the indicated age of 50 years.
- Studies in patients under the recommended age of 50 years with hematologic malignancies, renal or stem cell transplantation received the vaccine with no safety concerns.

Human Papillomavirus Vaccination

Human Papilloma Virus (HPV) Vaccination

Patients between ages >26 and <45 years, who are taking immunosuppressive medication and not previously vaccinated, vaccination is ***conditionally*** **recommended.**
Per ACIP: o HPV vaccination is recommended for all individuals ages 11 - 26 years. o HPV vaccination is recommended upon shared decision making for individuals ages 26 - 45 years.

Human Papillomavirus Vaccination (HPV)

- Immunosuppressive medications have been associated with an increased risk of cervical dysplasia and cervical cancer.
- HPV vaccination was found to be efficacious and tolerable in two studies of young patients with systemic lupus erythematosus.

Summary

- High dose or adjuvanted influenza vaccine is conditionally recommended over standard dose for adults with RMD on immunosuppression.
- Pneumococcal immunization is strongly recommended for adult RMD patients on immunosuppression.
- Recombinant VZV is strongly recommended for adults with RMD on immunosuppression.
- HPV vaccination is conditionally recommended for RMD patients ages 26 - 45 on immunosuppression.

Live-attenuated Vaccinations

Live-attenuated Vaccinations

Oral typhoid	Varicella
Intranasal influenza	Rotavirus
Oral polio	Yellow fever
Measles, mumps, rubella (MMR)	Cholera

Live-attenuated Vaccinations

In patients who are taking immunosuppressive medications, deferring live attenuated vaccines is ***conditionally* recommended.**

Holding immunosuppressive medication for an appropriate period before and 4 weeks after live attenuated virus vaccination is ***conditionally* recommended.**

Per ACIP, live vaccines should be administered 2 or more weeks before initiating therapies and should be withheld 3 months following such therapies. There are no recommendations for patients established on immunosuppressive medications.

Live-attenuated Vaccinations: Immunosuppressive Medications

- The recommended hold time of 4 weeks after live attenuated vaccination is conservative.
- Medication hold time after vaccination can be shortened if vaccination is critical and the risk of disease flare is high.
- Viremia is more prolonged after primary vaccination than after booster vaccinations.

Immunosuppressive medication	Hold before live-attenuated virus vaccine administration	Hold after live-attenuated virus vaccine administration
Glucocorticoids[a]	4 weeks	4 weeks
Methotrexate, azathioprine[b]	4 weeks	4 weeks
Leflunomide, mycophenolate mofetil, calcineurin inhibitors, oral cyclophosphamide	4 weeks	4 weeks
JAK inhibitors	1 week	4 weeks
TNF, IL17, IL12/23, IL23, BAFF/BLyS inhibitors	1 dosing interval[c]	4 weeks
IL6 pathway inhibitors	1 dosing interval[d]	4 weeks
IL1 inhibitors		
Anakinra	1 dosing interval[d]	4 weeks
Rilonacept	1 dosing interval[d]	4 weeks
Canakinumab	1 dosing interval[d]	4 weeks
Abatacept	1 dosing interval[c]	4 weeks
Anifrolumab	1 dosing interval[c]	4 weeks
Cyclophosphamide IV	1 dosing interval[c]	4 weeks
Rituximab	6 months	4 weeks
IVIG[e]		
300-400 mg/kg	8 months	4 weeks
1 gm/kg	10 months	4 weeks
2 gm/kg	11 months	4 weeks

JAK= Janus kinase; TNF=tumor necrosis factor; IL=interleukin; IVIG= intravenous immunoglobulin G; IV = intravenous

Live-attenuated Vaccinations and Immunosuppressive Medications

- The data behind use of live vaccines in patients on immunosuppressive therapy is limited to retrospective and observational studies.
- There is evidence to suggest the safety of csDMARDs and TNFi at the time of live attenuated virus vaccination, however the number of patients studied was small.
- Thus, the Voting Panel conditionally recommended against administering live attenuated virus vaccines to patients receiving those agents as well as other forms of immunosuppression.

Live-attenuated Vaccinations: Intravenous Immunoglobulin (IVIG)

- Antiviral antibodies contained in IVIG can interfere with replication of live-attenuated vaccines and reduce their efficacy.
- ACR and ACIP recommend an 8-11 month-delay (depending on IVIG dose).
  - ACIP allows for the administration of typhoid, yellow fever, LAIV, and rotavirus vaccines at any time before, concurrent with, or after administration of any antibody-containing product.
- There are some situations when earlier vaccination is preferred over delay. (MMR outbreak)

Rotavirus Vaccination

Rotavirus Vaccination

In infants exposed to **TNF inhibitors** in utero in the second or third trimester, giving live attenuated rotavirus vaccine within the first 6 months of life is ***conditionally* recommended**.

In infants exposed to **rituximab** in utero in the second or third trimester, delaying live attenuated rotavirus vaccine until >6 months of age is ***conditionally* recommended**.

Per ACIP, there are no timing recommendations rotavirus vaccination in infants exposed to TNF inhibitors or rituximab.

Rotavirus Vaccination

- Three observational studies found no adverse events in children who received live rotavirus vaccine after exposure to biologic disease modifying agents (DMARDs).
- Rituximab, on the other hand, has caused depleted or low levels of B lymphocytes in newborns exposed during the second or third trimester. This is because Rituximab can cross the placenta.
- B lymphocytes levels did return to normal in these infants within 6 months after birth. Thus, vaccination is recommended after 6 months of birth.

Live-attenuated Vaccinations: How long to hold medications?

- Direct evidence for optimal medication hold time is lacking.
- csDMARDs:
  - Pre-vaccination hold time of four weeks
  - Chosen to reflect their prolonged duration of action
- bDMARD:
  - Pre-vaccination hold time of one dosing interval
- Post vaccination: DMARD to be held for four weeks.

Scheduling Vaccines

Scheduling Vaccines

Giving multiple vaccines on the same day rather than giving each individual vaccination on a different day is ***conditionally recommended.***

Administering >1 vaccination on a single day is a routine practice and is supported by the ACIP in both pediatric and adult medicine.

Scheduling Vaccines

- Shared decision-making should be considered due to concerns about potential for reactogenicity or disease flare with multiple vaccinations.
- Missed vaccination opportunities should be avoided, if possible.
- Close contacts of immunosuppressed patients should receive all age-appropriate vaccination to avoid vaccine preventable diseases.

Limitations

Limitations

- Pneumococcal (PCV15 and PCV20) and smallpox/monkeypox vaccines were not included since they were not approved at the time of the project plan.
- The impact of NSAIDs and Acetaminophen use was not included.
- COVID-19 vaccinations were not included due to the ever-changing nature of COVID 19 pandemic.
- There are no studies assessing the impact of holding medications around the time of vaccinations for vaccines other than the influenza vaccine.

In Summary:

- Indicated vaccinations should be given whenever possible.
- The guideline is complementary to those from ACIP/CDC and AAP.
- Decision to hold medication around vaccination should consider:
  - Disease
  - Disease activity
  - Risk of vaccine preventable infection
- Shared decision-making with patients is a key component of any vaccination strategy.

Review Questions

Review Question 1

Which of the following is not a resource that can be used for information regarding vaccines?

A. The Orange Book
B. The Pink Book
C. Centers for Disease Control (CDC)
D. Advisory Committee on Immunization Practices (ACIP) Recommendations

Review Question 1

Which of the following is not a resource that can be used for information regarding vaccines?

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B. The Pink Book
C. Centers for Disease Control (CDC)
D. Advisory Committee on Immunization Practices (ACIP) Recommendations

Review Question 2

A patient with gout is on prednisone 20 mg daily and is due for their annual influenza vaccine. When is the most appropriate time to give this patient their vaccine?

A. When their prednisone dose is lowered to <20 mg daily.
B. When their prednisone dose is lowered to <10 mg daily.
C. At their soonest convenience.
D. This patient is not indicated for an influenza vaccine at this time.

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C. At their soonest convenience.

For patients taking the equivalent of:
Prednisone ≥20mg daily: influenza vaccination is *conditionally* recommended. Deferring non-live attenuated vaccinations, other than influenza vaccination, until glucocorticoids are tapered to the equivalent of prednisone <20mg daily is *conditionally* recommended.

Review Question 3

A patient with a history of rheumatoid arthritis is inquiring about their annual flu vaccine. They have not received a dose for this year's seasonal flu. The patient is taking methotrexate. What would be the most appropriate consultation point regarding the influenza vaccine for this patient?

A. Discuss that the patient should complete their methotrexate course prior to influenza vaccination for optimal immunogenicity.
B. Recommend for the patient to ask their rheumatologist if disease activity allows for the patient to hold methotrexate for 2 weeks after the influenza vaccination for optimal immunogenicity.
C. Recommend for the patient to ask their rheumatologist if disease activity allows for the patient to hold methotrexate for 2 weeks before the influenza vaccination for optimal immunogenicity.
D. Discuss that the patient is not indicated for a seasonal influenza vaccine due to their rheumatoid arthritis. Immunogenicity will be suboptimal.

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B. Recommend for the patient to ask their rheumatologist if disease activity allows for the patient to hold methotrexate for 2 weeks after the influenza vaccinat

Holding methotrexate (MTX) for 2 weeks after influenza vaccination is *conditionally* recommended, if disease activity allows.

Review Question 4

A patient on leflunomide was instructed to receive a yellow fever vaccine by their travel health provider. Their rheumatologist would like to hold their leflunomide prior to giving the yellow fever vaccine. Which of the following would be an appropriate recommendation on the timing of yellow fever vaccine and the patient's leflunomide medication?

A. Leflunomide does not need to be held since yellow fever immunization is an inactivated vaccine.

B. Leflunomide should not be held because studies have shown a high incidence of disease flare when holding.

C. Leflunomide should be held 1 day, if disease activity permits, before giving the vaccine.

D. Leflunomide should be held 4 weeks before, if disease activity permits, before giving the vaccine.

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D. Leflunomide should be h[illegible] if disease activity permits, bef[illegible]

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Methotrexate, azathioprine[b]	4 weeks	4 weeks
Leflunomide, mycophenolate mofetil, calcineurin inhibitors, oral cyclophosphamide	4 weeks	4 weeks

Review Question 5

A 55-year-old patient with systemic lupus erythematosus is indicated to get an influenza vaccine and an inactivated shingles vaccine. What would be the best way to schedule these vaccines?

A. Patients with lupus are not indicated to receive a shingles vaccine.
B. Schedule these vaccines 2 weeks apart.
C. Schedule these vaccines 4 weeks apart.
D. Schedule these vaccines on the same day.

Review Question 5

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References

1. American College of Rheumatology. https://www.rheumatology.org/Practice-Quality/Clinical-Support/Clinical-Practice-Guidelines
2. Advisory Committee on Immunization Practices (ACIP). Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 22 Feb. 2023, https://www.cdc.gov/vaccines/acip/index.html.
3. "Pinkbook: Course Book: Epidemiology of Vaccine Preventable Diseases." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 19 Aug. 2021, https://www.cdc.gov/vaccines/pubs/pinkbook/index.html.
4. "Immunization Schedules." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 10 Feb. 2023, https://www.cdc.gov/vaccines/schedules/index.html.
5. Abu-Shakra M, Press J, Varsano N, et al. Specific antibody response after influenza immunization in systemic lupus erythematosus. J Rheumatol 2002;29:2555–7.
6. Crowe SR, Merrill JT, Vista ES, et al. Influenza vaccination responses in human systemic lupus erythematosus: impact of clinical and demographic features. Arthritis Rheum 2011;63:2396–406.
7. Ristow SC, Douglas RG Jr, Condemi JJ. Influenza vaccination of patients with systemic lupus erythematosus. Ann Intern Med 1978; 88:799–9.
8. Borba EF, Seed CG, Precioso SG, et al. Influenza AH1N1 vaccination of patients with SLE: can antimalarial drugs restore diminished response under immunosuppressive therapy? Rheumatology (Oxford) 2012;51:1061–9.
9. Campos LM, Silva CA, Aikawa NE, et al. High disease activity: an independent factor for reduced immunogenicity of the pandemic influenza A vaccine in patients with juvenile systemic lupus erythematosus. Arthritis Care Res (Hoboken) 2013;65:1121–7.
10. Guissa VR, Pereira RM, Sallum AM, et al. Influenza A H1N1/2009 vaccine in juvenile dermatomyositis: reduced immunogenicity in patients under immunosuppressive therapy. Clin Exp Rheumatol 2012;30: S83–9.
11. Adler S, Krivine A, Wiek J, et al. Protective effect of AH1N1 vaccination in immune-mediated disease: a prospectively controlled vaccination study. Rheumatology (Oxford) 2012;51:695–700.
12. Ribeiro AC, Guedes LK, Moraes JC, et al. Reduced seroprotection after pandemic H1N1 influenza adjuvant-free vaccination in patients with rheumatoid arthritis: implications for clinical practice. Ann Rheum Dis 2011;70:2144–7.
13. Park JK, Lee MA, Lee EY, et al. Effect of methotrexate discontinuation on efficacy of seasonal influenza vaccination in patients with rheumatoid arthritis: a randomised clinical trial. Ann Rheum Dis 2017;76: 1559–65.
14. Park JK, Lee YJ, Shin K, et al. Impact of temporary methotrexate discontinuation for 2 weeks on immunogenicity of seasonal influenza vaccination in patients with rheumatoid arthritis: a randomised clinical trial. Ann Rheum Dis 2018;77:898–904.
15. Araujo CS, Medeiros-Ribeiro AC, Saad CG, et al. Two-week methotrexate discontinuation in patients with rheumatoid arthritis vaccinated with inactivated SARS-CoV-2 vaccine: a randomised clinical trial. Ann Rheum Dis 2022;81:889–97.
16. Arunachalam de Silva AN, Frommert LM, Albach FN, et al. Pausing methotrexate improves immunogenicity of COVID-19 vaccination in elderly patients with rheumatic diseases. Ann Rheum Dis 2022;81: 881–8.
17. Kleine JL, Krotz AJ, Birbara C, et al. Immune responses following administration of influenza and pneumococcal vaccines to patients with rheumatoid arthritis receiving adalimumab. J Rheumatol 2007; 34:272–9.
18. Krotz AJ, Schechtman J, Teeter M, et al. Vaccine responses in patients with rheumatoid arthritis treated with certolizumab pegol: results from a triple-blind randomized phase IV trial. J Rheumatol 2014;41:646–57.
19. Heuvele M, Clemon P, Guery B, et al. Risk factors for severe bacterial infections in patients with systemic autoimmune diseases receiving rituximab. Clin Rheumatol 2014;33:799–805.
20. Shea AM, Eskelsberg J, Weycker D, et al. Rates of pneumococcal disease in adults with chronic medical conditions. Open Forum Infect Dis 2014;1:ofu028.
enters for Disease Control and Prevention. Use of 13-valent pneumococcal conjugate vaccine and 23-valent pneumococcal conjugate
21. Dhar JP, Essenmacher L, Dhar R, et al. The safety and immunogenicity of Quadrivalent HPV (qHPV) vaccine in systemic lupus erythematosus. Vaccine 2017;35:2642–6.
22. Mok CC, Ho LY, Fong LS, et al. Immunogenicity and safety of a quadrivalent human papillomavirus vaccine in patients with systemic lupus erythematosus: a case-control study. Ann Rheum Dis 2013;72: 659–64.
23. Feldman CH, Liu J, Feldman S, et al. Risk of high-grade cervical dysplasia and cervical cancer in women with systemic lupus erythematosus receiving immunosuppressive drugs. Lupus 2017;26:662–9.
24. Garland SM, Brotherton JM, Moscicki AB, et al. HPV vaccination of immunocompromised hosts. Papillomavirus Res 2017;4:35–8.
25. Kim SC, Glynn RJ, Giovannucci E, et al. Risk of high-grade cervical dysplasia and cervical cancer in women with systemic inflammatory diseases: a population-based cohort study. Ann Rheum Dis 2010; 74:1360–7.
26. Kim SC, Schneeweiss S, Liu J, et al. Biologic disease-modifying antirheumatic drugs and risk of high-grade cervical dysplasia and cervical cancer in rheumatoid arthritis: a cohort study. Arthritis Rheumatol 2016;68:2106–13.
27. Watstrom H, Frisell T, Sparen P, et al. Do RA or TNF inhibitors increase the risk of cervical neoplasia or of recurrence of previous neoplasia? A nationwide study from Sweden. Ann Rheum Dis 2016; 75:1272–8.
28. Dhar JP, Essenmacher L, Dhar R, et al. The safety and immunogenicity of Quadrivalent HPV (qHPV) vaccine in systemic lupus erythematosus. Vaccine 2017;35:2642–6.
Mok CC, Ho LY, Fong LS, et al. Immunogenicity and safety of a quadrivalent human papillomavirus vaccine in patients with systemic lupus erythematosus: a case-control study. Ann Rheum Dis 2013;72: 659–64.
29. Stapleton JT, Wagner N, Tuetken R, et al. High dose trivalent influenza vaccine compared to standard dose vaccine in patients with rheumatoid arthritis receiving TNF-alpha inhibitor therapy and healthy controls: results of the DMID 10–0076 randomized clinical trial. Vaccine 2020;38:3934–41.
30. Colmegna I, Ureche ML, Rodriguez K, et al. Immunogenicity and safety of high-dose versus standard-dose inactivated influenza vaccine in rheumatoid arthritis patients: a randomised, double-blind, active-comparator trial. Lancet Rheumatol 2020;2:e14–23.
31. Beaulieu DB, Ananthakrishnan AN, Martin C, et al. Use of biologic therapy by pregnant women with inflammatory bowel disease does not affect infant response to vaccines. Clin Gastroenterol Hepatol 2016;16:99–105.
32. Chanelle-Redfern H, Lee S, Julson B, et al. Suboptimal vaccination administration in mothers with inflammatory bowel disease and their biologic-exposed infants. Inflamm Bowel Dis 2022;28:79–86.
33. Lee KE, Jung SA, Park SH, et al. Influence of anti-tumor necrosis factor-alpha therapy to pregnant inflammatory bowel disease women and their children's immunity. Intest Res 2016;17:237–43.
34. Ling J, Koren G. Challenges in vaccinating infants born to mothers taking immunoglobulin biologicals during pregnancy. Expert Rev Vaccines 2016;15:239–56.
35. Zhang, Jiangxu, and Alin Tao. "Antigenicity, Immunogenicity, Allergenicity." Allergy Bioinformatica vol. 8 175–186. 2 Nov. 2015, doi:10.1007/978-94-017-7444-4_11

The Speakers would like to thank:

Dr. Havan Truong, PharmD, CSP
Dr. Richard Dang, PharmD, BCACP, APh, FCPhA
Keck Medicine of USC Specialty Pharmacy
USC Alfred E. Mann School of Pharmacy and Pharmaceutical Sciences