Vaccinations and Immunocompromised Children

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Disclosures

- I am involved in a study of the shedding and safety of the live-attenuated influenza vaccine (Flumist) in HIV-infected children, I receive a small percentage of salary support as part of a larger grant from MedImmune
- Sanofi-Pasteur provides vaccine and one laboratory assay for a study I am doing on high-dose influenza vaccine in immunocompromised children
- Some of the guidelines I will discuss include off-label (non-FDA-approved) use of vaccines

Learning Objectives

- Understand basic principles in vaccinating immunocompromised children
- Increase understanding of when it is safe to use live-virus vaccines in certain immunocompromised children
- Know which vaccines have specific indications for certain immunocompromised children
- Develop a general understanding of travel-related vaccines and which ones are safe in immunocompromised children

Outline

- Basic concepts, Background information
- Live Virus Vaccines
- Vaccines with indications specifically for immunocompromised
- Disease/Condition-specific vaccine information
- Travel

BASIC CONCEPTS, BACKGROUND

Resources

- CDC schedule "Recommended Vaccinations Indicated for Adults Based on Medical and Other Indications"
  - Immunocompromising conditions (incl HIV), Pregnancy, MSM, Heart dz, Asplenia, Chronic Liver dz, Kidney failure/ESRD/on dialysis, Diabetes, Health-care personnel
  - FYI: The Catch-Up schedule lists the minimum intervals b/w vaccines and minimum ages
- Am J Transplantation Jan 2013 Supplement, entire volume dedicated to ID incl vaccination recs for SOT
- "2013 IDSA Clinical Practice Guideline for Vaccination of the Immunocompromised Host
- WHO "International Travel and Health: Chapter 9 Special Groups of Travellers"

Immunocompromise is common

- In the US, there are >76,000 children/youth age 13-24 with HIV (CDC, 2011 data)
- >14,000 diagnoses of cancer each year in 0-19 year-olds (CDC, 2005-2009 data)
- Many more on immunosuppression for rheumatologic diseases, IBD, or other autoinflammatory conditions
- Handful of kids with primary immunodeficiencies

Why do we all need to know this?

- There are a lot of immunocompromised patients out there, we will all care for them
- Vaccines are an opportunity to prevent an illness, but they aren't without risk
- Care for complicated patients can be fractured and as a group they are not as well immunized
  - All care providers need to work together to vaccinate
- We also can recommend vaccinations for family/household members

Who is responsible for vaccinating immunocompromised children?

A. PCP
B. Specialist
C. Both – they need to communicate and create a plan
D. A different model

And the answer is…

- There's no right answer
- I think a model that promotes the medical home and keeps the PCP actively involved is the best
  - PCPs are the vaccine experts
  - But specialists should understand risks/benefits of certain vaccines with respect to the child's specific condition/treatment
- Some children are so complicated that they'll require an individualized solution

HOW DO I KNOW HOW IMMUNOSUPPRESSED A CHILD IS?

Definitions of High- and Low-Level Immunosuppression (adapted from IDSA Guidelines)

- High-level immunosuppression:
  - With combined primary immunodeficiency disorder (eg, severe combined immunodeficiency)
  - Receiving cancer chemotherapy
  - Within 2 months after solid organ transplantation
  - HIV-positive with CD4 count <200 cells/mm^3 for adults and adolescents and percentage <15% for infants and children

Definitions of High- and Low-Level Immunosuppression (adapted from IDSA Guidelines)

- High-level immunosuppression:
  - Receiving daily corticosteroid therapy of ≥20 mg (or >2 mg/kg/day for <10kg) of prednisone or equivalent for ≥14 days
  - Receiving a biologic immune modulator that is a TNF-alpha blocker or rituximab.
    - NOTE – this is an ever-increasing group of medicines, they are not all equally immunosuppressive

Definitions of High- and Low-Level Immunosuppression (adapted from IDSA Guidelines)

- Low-level immunosuppression:
  - Asymptomatic HIV-positive patients with CD4 count 200–499 cells/mm^3 for adults and adolescents and percentage of 15%–24% for infants and children
  - Receiving a lower daily dose of systemic corticosteroid than for high-level immunosuppression for ≥14 days or receiving alternate-day corticosteroid therapy
  - Receiving methotrexate ≤0.4 mg/kg/week, azathioprine ≤3 mg/kg/day, or 6-mercaptopurine ≤1.5 mg/kg/day.

Definitions of High- and Low-Level Immunosuppression (adapted from IDSA Guidelines)

- <u>After HSCT:</u>
  - Duration of high-level immunosuppression is highly variable
  - Depends on:
    - type of transplant (longer for allogeneic vs. autologous)
    - type of donor
    - stem cell source, and
    - post-transplant complications such as GVHD and their treatments.

GENERAL CATEGORIES OF VACCINES AND THE IMMUNE RESPONSE

Types of vaccines by immune response

- Inactivated virus, protein, toxoid, protein conjugate, viral-like-particles
- Polysaccharide
- Live-attenuated

Which of the following describes the immune response to polysaccharide vaccines?

A. Eventual development of high affinity antibodies
B. No development of memory immune response
C. T-cell mediated
D. Better than non-polysaccharide vaccines for ≥2yo
E. All of the above
F. None of the above

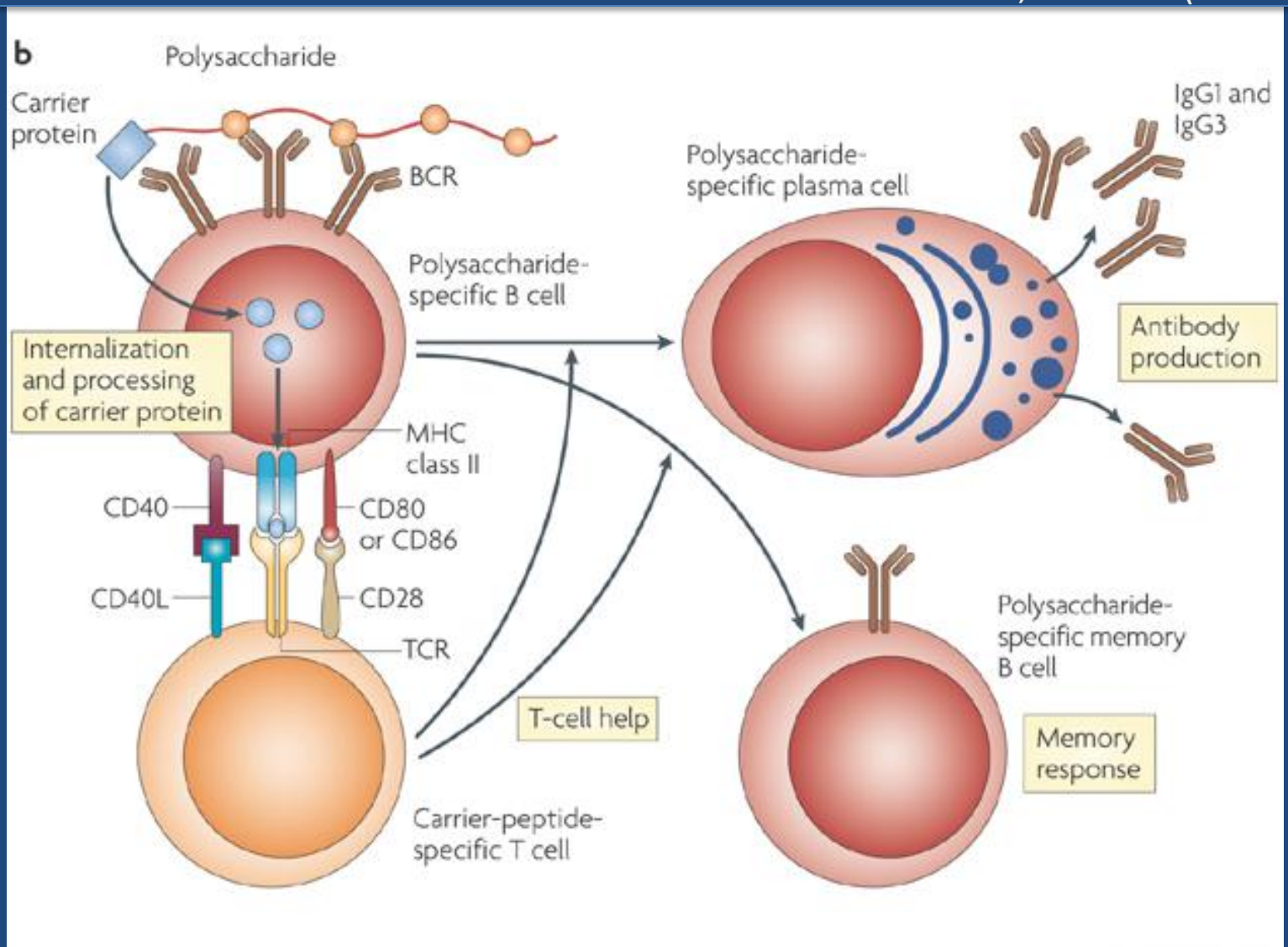
Why do we not routinely give live-virus vaccines to children under 12 months?

A. They primarily have T-cell dependent immunity
B. They don't have marginal-zone B cells
C. Maternal antibodies can interfere
D. Immature immune systems mean higher chance of vaccine-related adverse events
E. All of the above
F. None of the above

Non-polysaccharide vaccines

(example of protein-conjugated polysaccharide vacc)

Nat Rev Immun **9**, 213-220 (March 2009)



Polysaccharide vaccines

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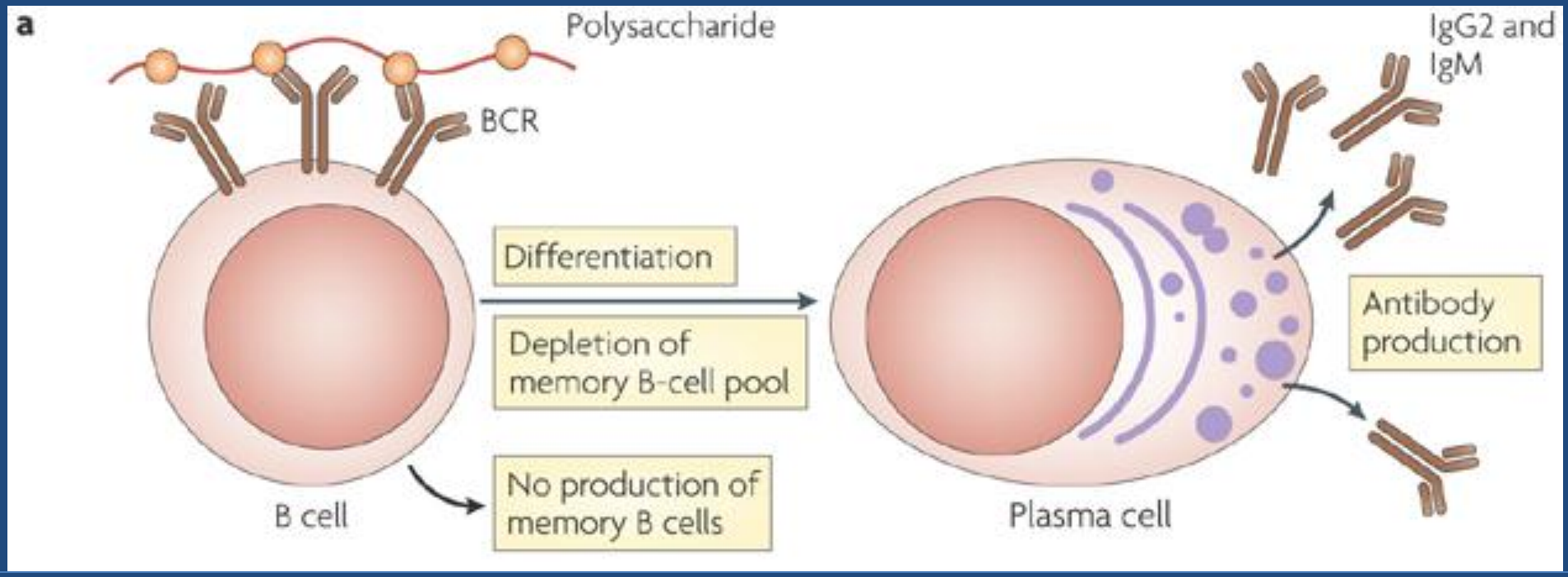


Live-attenuated vaccines

- Compared to inactivated:
  - Virus enters body and replicates
  - Replication leads to higher antigen content
  - Replication leads to more prolonged antigen persistence (giving time to develop immune response)
  - Greater intensity of innate responses
  - Replication leads to MHC I and II presentation of antigen and improved memory immune response
  - Usually leads to higher antibody responses

GENERAL RULES REGARDING TIMING OF VACCINATIONS

Timing of vaccinations

- *Vaccinate early and vaccinate often*
- If possible, vaccinate prior to immunosuppression
  - Pediatrics: Many vaccines are approved to younger ages than recommended on the CDC schedule (e.g. HPV approved to 9 yo)
- Inactivated:
  - Avoid within 2 weeks of initiation of immunosuppression
- Live:
  - Avoid within 4 weeks of initiation of immunosuppression

When to Delay Vaccines

- This is for non-live vaccines that are indicated by age and/or condition
- Delaying vaccines would be indicated:
  - If patient is severely immunosuppressed ➔poor immune response and may be futile
  - If patient is immunosuppressed but there is a foreseeable time in the future when the patient will be on lower or no immunosuppression
- A vaccine can always be repeated/boosted in the future

HOUSEHOLD MEMBERS, “COCCOONING” OUR VULNERABLE PATIENTS

Household members of immunocompromised

- Should receive all age-appropriate vaccinations according to CDC schedules
  - Including: Rota, MMR, VAR, MMR-V, Zostavax
  - Also travel: Yellow Fever, Oral Typhoid

- Should receive yearly influenza vaccine
  - Avoid live-attenuated influenza vaccine if there is a patient with: SCID, w/in a few months of BMT or post-BMT with GVH

Household members of immunocompromised

- Should NOT receive oral polio or smallpox vaccines
- Immunocompromised indivs should avoid:
  - (For severely immunocompromised) Changing diapers w/in 4 weeks of rotavirus vaccination in babies (transmission has never been documented even though shedding is well-documented)
  - Avoid contact with VAR/ZOS recipient who develops skin lesions after vaccination until lesions heal

A COUPLE MORE POINTS…

Miscellaneous

- Influenza vaccine:
  - Everyone should get yearly influenza vaccines
  - Avoid live-attenuated influenza vaccine (LAIV) in most immunocompromised people

- Vaccines have not been shown to be associated with rejection post-transplant, GVH post-BMT, or with exacerbation of inflammatory conditions

LIVE VIRUS VACCINES

6-yo M with h/o of severe atopic dermatitis since birth, eosinophilic esophagitis with peripheral eosinophilia, RAD, multiple severe food allergies w/anaphylaxis, history of 3 HSV/Zoster skin infections after oral steroid treatments, has only had one VZV/MMR at 12 mos of age. Would you give him a booster?

A. Yes, VZV only
B. Yes, MMR only
C. Yes, both VZV and MMR
D. No

3yr 3mo M with autoimmune hepatitis is being evaluated for a liver transplant (not yet listed). He is up-to-date on all his age-appropriate vaccines. Would you vaccinate with VAR or MMR?

A. Yes, VZV only
B. Yes, MMR only
C. Yes, both VZV and MMR
D. No

12-mo F, in your practice since birth, doing well without medical problems, normal growth and development. Family history negative except that her (now) 9-yo sister had bacterial meningitis at 12-mos of age and is completely fine now?

A. Yes, VZV only
B. Yes, MMR only
C. Yes, both VZV and MMR
D. No

1st case, 6-yo, presents with stroke-like symptoms (vomiting, HA, giggling, urinary incontinence, L leg paresthesias, L body paresis). Found to have 5 areas of acute stroke on MRI, c/w CNS vasculitis. What viruses are associated with CNS vasculitis?

A. Hepatitis C
B. CMV
C. JC virus
D. VZV
E. HIV
F. All of the above
G. None of the above

3rd case, 14-mo in hospital for 3 weeks with severe hemolytic anemia. MMR/VAR given 1 month prior to admission. New disseminated vesicular rash and encephalopathy. What do you test for?

A. VZV skin
B. VZV CSF
C. Measles/mumps/rubella CSF
D. Brain biopsy for VZV, measles, mumps, rubella
E. Throat PCR measles/mumps/rubella
F. A, B, C, E
G. All of the above

Live virus vaccines

- US routine schedule:
  - Varicella (VAR, MMR-V, ZOS)
  - Measles, Mumps, Rubella (MMR, MMR-V)
  - Rotavirus
  - Live-attenuated influenza vaccine (LAIV)

- Won't talk about LAIV b/c there is an alternative inactivated influenza vaccine

- Refer to "Travel" section at end of talk for oral Typhoid and Yellow Fever

A couple of pearls about live virus vaccines

- Period of replication is usually <u>≤2 weeks</u>
- Maternal antibodies can interfere with the immune response in children under 12 mos of age
- Concern for disseminated infection with attenuated virus
  - Well-documented vaccine-type varicella infections and measles post-vaccination in immunocompromised (also polio)

So, who can get MMR/VAR?

- Pre-immunosuppression:
  - Give at least 4 weeks prior to immunosuppression
  - Children:
    - MMR/VAR: Can give as young as 6 months
    - Ideally 1st dose after 12 mos of age
  - Adults:
    - MMR/VAR: With no history of immunity and if can be given ≥ 4 weeks prior to immunosuppression
    - Zostavax: Adults ≥ 50yo, with history of immunity and can be given ≥ 4 weeks prior to immunosuppression

Who can get MMR/VAR?, cont'd

- Post-immunosuppression:
  - Minimally-immunosuppressed and no prior immunity
    - VAR/ZOS: On long-term low-level immunosuppression , including post-transplant, chronic inflammatory disorders
- Other immunocompromised
  - HIV with CD4 count ≥ 200 or ≥ 15%
  - At least 3 mos after cancer chemotherapy and at least 2 years after BMT (if not still immunosuppressed)

Who can get MMR/VAR?, cont'd

- More Categories of immunocompromised
  - Primary immune deficiency without defective T-cell mediated immunity
    - » Complement deficiency
    - » Chronic granulomatous deficiency
    - » Cyclic neutropenia
    - » IgA deficiency
    - » Partial DiGeorge: Those with ≥500 CD3 T cells/mm^3, ≥200 CD8 T cells/mm^3, and normal mitogen response should receive MMR and VAR

Who can't get MMR/VAR?

- Anyone who will be significantly immunosuppressed within 4 weeks of receipt of the vaccine
- HIV with CD4 ≤ 200 or ≤ 15%

- MMR not recommended in people with chronic inflammatory disease on immunosuppression – risk/benefit not there in the US

Who can't get MMR/VAR/ZOS?

- Primary immunodefiencies:
  - Major antibody defects (SCID, CVID)
  - Innate defects of cytokine production
  - Leukocyte adhesion deficiency (LAD), Chediak-Higashi
  - Combined immunodefiencies
  - Defects of IFN-gamma/IL-12, or IFN-alpha
  - Complete DiGeorge and partial DiGeorge who don't meet criteria on prior slide
- Anyone moderately or severely immunosuppressed

Example: VAR/MMR in liver transplant

- (Japan) 58 subjects, vaccinated pre-transplant then boosted if antibody levels fell below protective level
  - 1 significant AE, occurred during pre-transplant vaccination, allergic reaction with diffuse hives
  - Seroconversion to measles, mumps, rubella, varicella after primary vaccination: 82%, 90%, 100%, 95% respectively
  - Seroconversion after revaccination (for waning immunity): 85%, 100%, 100%, 71%
  - 12 subjects with dz, none w/in 6mos post-transplant, all had low antibody levels: 3 measles, 7 mumps, 5 varicella
  - 9 primary vaccine failures, 4 were age 6-10 mos at time of vaccination

Transplantation 2002;74(4):543–550

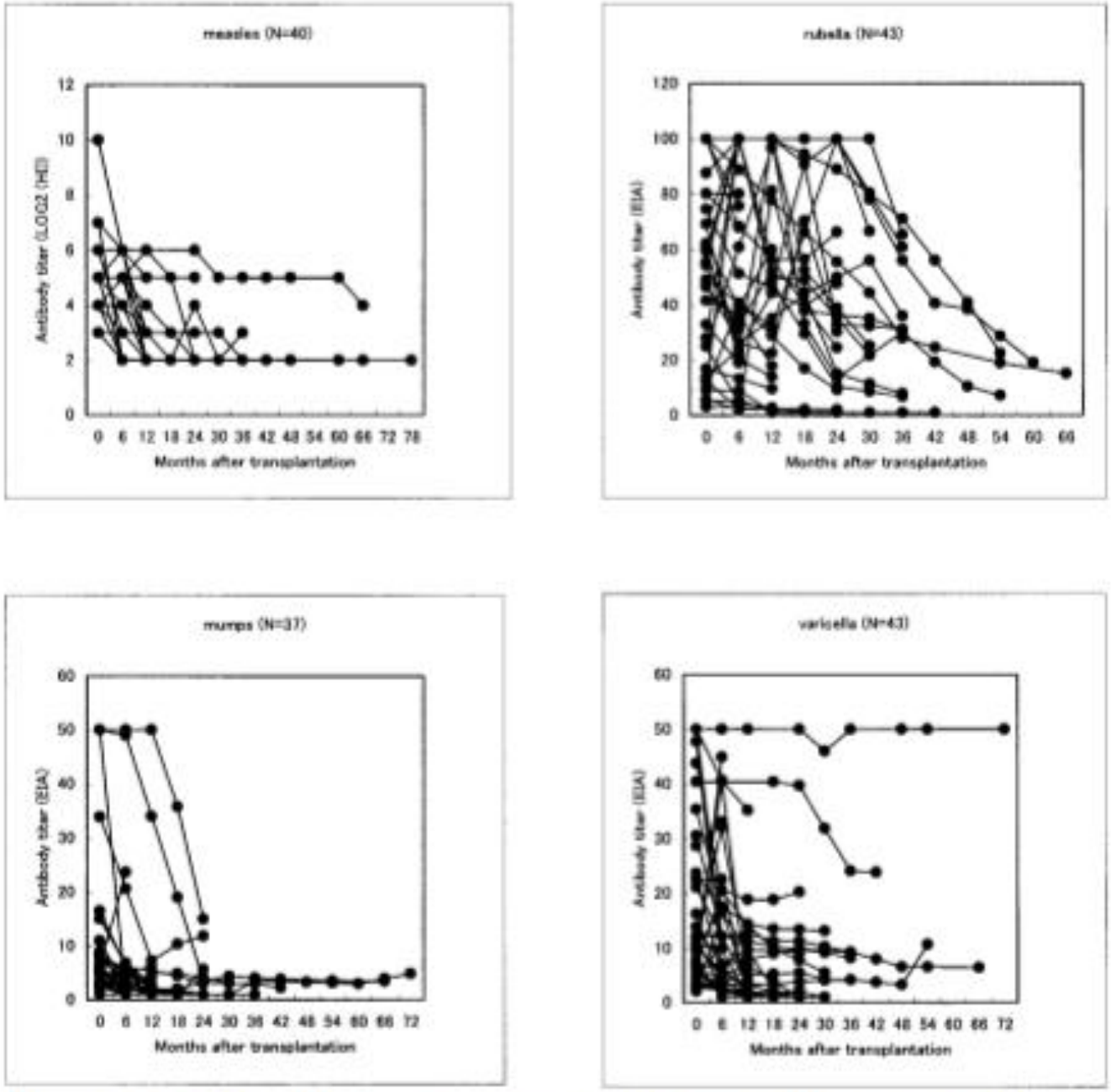


FIGURE 3. The transition of antibody titers against four viruses after transplantation. The posttransplantation follow-up time ranged from 6 to 78 months (median time 30 months). Antibody titers against these viruses exhibited a decreasing trend over extended periods of time. However, antibody titers were relatively retained for 6 months after transplantation.

Live-virus vaccines in Rheumatology patients receiving biologics

- VERY few studies!
- 5 pts receiving MTX+etanercept, MMR booster, safe and immunogenic (Rheumatology, 2009;48 (2):144-148)
- 17 pts taking infliximab received yellow fever vaccine (during epidemic in Brazil), safe and immunogenic (Arth Care & Res, 2010;62(6):896-898)
- Study of safety and dz exacerbation in JIA
  - 137 pts age 4-9, 68 received MMR booster, 69 no vaccine
  - Biologics stopped at 5-half lives prior (2wks prior and 1 wk after for etanercept, 2 days prior and 3 days after for anakinra)
  - 9 pts taking biologics received vaccine
  - Conclusions: safe no worsening of disease
  - (JAMA. 2013;309(23):2449-2456)

You have a 16-yo F who is on Remicade for JIA. She has only received one dose each of VAR and MMR. She is going on a 6-week mission with her church to Ethiopia this summer. What do you do?

A. Give her both VAR and MMR now
B. Give her VAR only knowing you can treat with acyclovir if complications arise
C. Give MMR only knowing you have a treatment if she does get varicella
D. Check antibodies, vaccinate if negative
E. Vaccinate with both if rheumatologist and patient say they can hold her medicines for a few weeks before and after
F. Give IVIG just prior to departure
G. Send her to travel clinic

You have a 4-yo on steroids for SLE for 1 month. Dose is 20mg PO daily. You don't know whether it will be decreased in the future. There is varicella and measles in the community. What do you do today?

A. Give both, will probably be fine
B. Give VAR knowing at least you can give acyclovir for complications
C. Give neither
D. Find out steroid plan from rheumatologist
E. Give a dose of IVIG
F. Check antibody titers to varicella and measles

Rotavirus

- Do not give if you know of or suspect an immunodeficiency
  - Could be easy to give before diagnosis of immunodeficiency
  - There are no safety/efficacy studies in immunocompromised children
    - Safe in small numbers of HIV+, more data to come (NEJM, 2010; 362:289-298)
    - NEJM article w/3 SCID babies and persistent + stool (NEJM, 2010; 362:314-319); VAERS report of 9 SCID babies all dx post-vacc, all w/diarrhea, all survived (Vaccine. 2010 Sep 14;28(40):6609-12)
  - CDC states to use judgment b/c severe rotavirus is well-reported in immunodeficient kids
  - At least rotavirus doesn't spread systemically like polio, varicella, or measles; NO DEATHS OR LONG-TERM EFFECTS ASSOCIATED WITH ROTAVIRUS VACCINES

VACCINES INDICATED FOR IMMUNOCOMPROMISED:

PNEUMOCOCCAL AND MENINGOCOCCAL VACCINES

What approx % of Strep pneumo invasive disease is estimated to be caused by the 13 types in PCV13 and the additional 10 types in PPSV23 respectively (CDC data)?

A. 28%, 47%
B. 40%, 33%
C. 55%, 21%
D. 66%, 18%
E. None of the above

2 Strep pneumo vaccines

- Pneumococcal conjugate (PCV13)
  - Healthy children: age 2, 4, 6, and 12-15 mos
  - Healthy children: age 14-59 months who have only received PCV7
  - Children 24-71 mos with high-risk: 1 dose if have received 3 in past, 2 if received < 3 in past
    - High-risk: chronic heart or lung dz, diabetes, + all in next bullet
  - Children age 6-18 yo with high-risk conditions:
    - Immunocompromising conditions, functional or anatomic asplenia, cochlear implants or CSF leaks
  - Adults age ≥ 19 yo with high-risk conditions

2 Strep pneumo vaccines

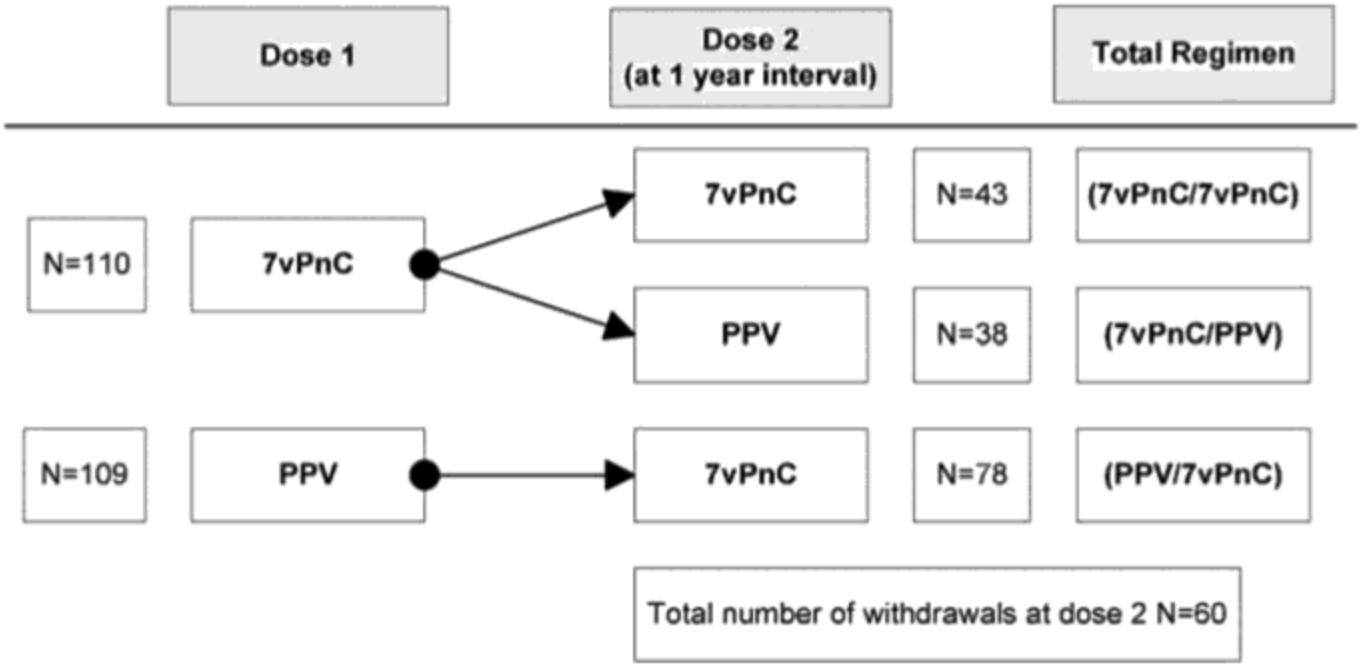
- Pneumococcal polysaccharide (PPSV23)
  - Children with medical conditions (see above for PCV13):
    - administer 1 dose at least 8 weeks after last PCV13
    - 2nd dose 5 years after first in children with functional/anatomic asplenia or immunocompromising conditions
  - Healthy adults: all ≥ 65 yo
  - Adults <65yo with medical problems (too many to list, refer to CDC guidelines)

Pneumococcal vaccines

- Basic schedule for immunocompromised:
  - PCV13: 1 dose
  - PPSV23: 1st dose ≥ 8 weeks after PCV13 and a second dose 5 years later
    - 1st dose at 2 years of age or older
    - Total of 2 lifetime doses (see CDC schedule for indications of 2nd dose)
  - If someone has already received PPSV23 and should receive PCV13, dose should be given ≥ 8wks after PPSV23 (June 2013 ACIP Guidelines)

Why PCV13 first?

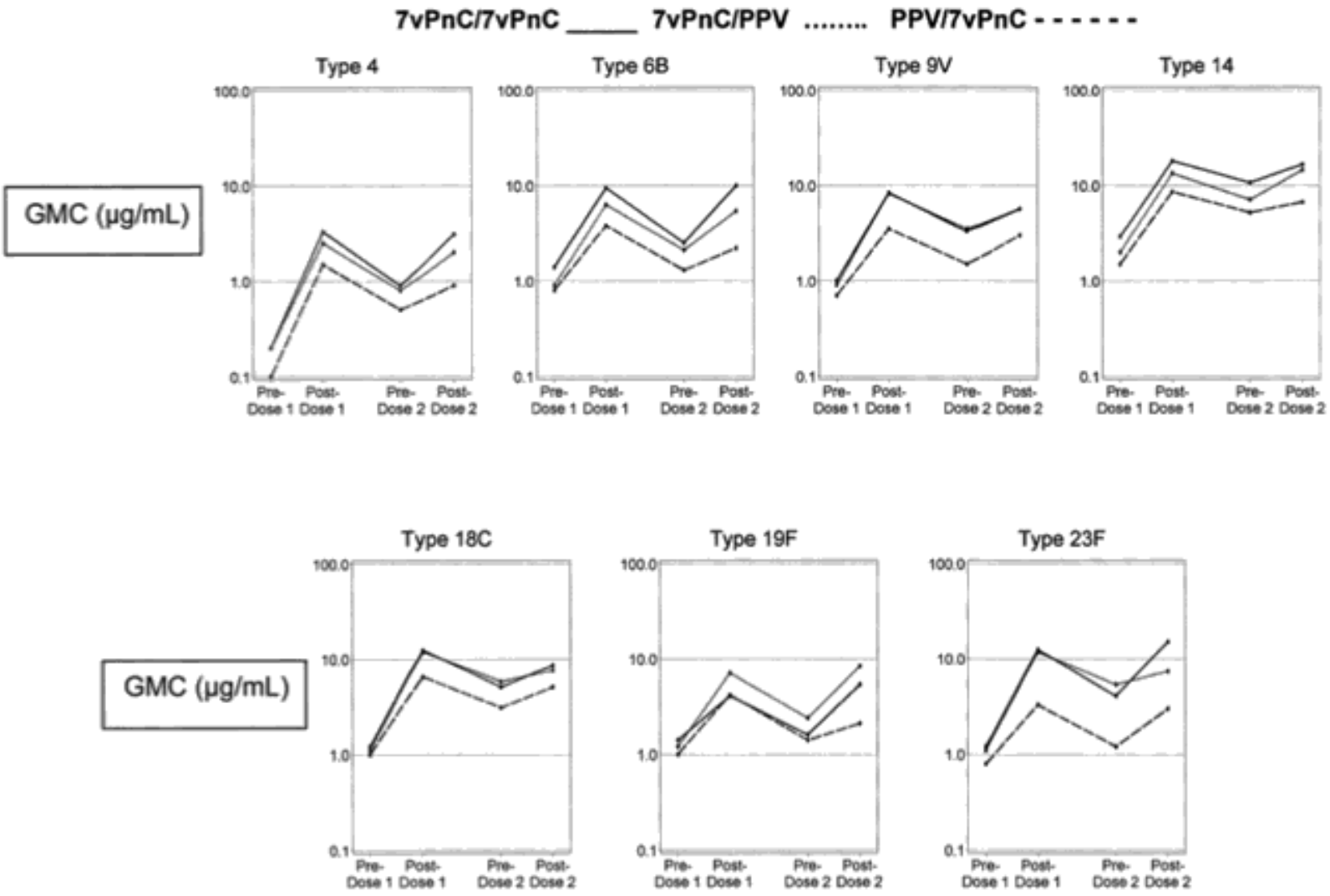
Vaccine administration scheme showing the number of subjects, including those who withdrew from the study, in each subgroup. 7vPnC, 7-valent conjugated pneumococcal polysaccharide vaccine; PPV, 23-valent pneumococcal polysaccharide vaccine.



de Roux A et al. Clin Infect Dis. 2008;46:1015-1023

Clinical Infectious Diseases

Antipneumococcal polysaccharide binding antibody responses elicited during the immunization series.



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Deficiencies of which of the following complement system proteins have been associated with increased risk of Neisseria meningitidis infection?

A. C1
B. C3
C. C4
D. C5
E. C8
F. Properidin
G. All except C1, C4
H. All except properidin

Meningococcal vaccines

- MenHibrix (HiBMenCY):
  - Approved down to 6 weeks of age; 4-dose series at 2, 4, 6, and 12-15 mos
- Menactra (MenACYW-D) :
  - Approved age 9 mos-55 years; Single dose 2-55yrs; 2-dose series 9-23 mos
  - Recommend to NOT give under 2 yrs to avoid interference with PCV13 vaccination
- Menveo (MenACYW-CRM):
  - Approved age 2mos-55 years; 4-dose infant series at 2, 4, 6, 12-15 mos, also a 2-dose series at 7-9 mos up to 23 mos
- Menomune (MPSV4): a polysaccharide vaccine
  - Approved for ≥ 2yo
  - The only one approved for adults over 55, recommended if never received MCV4 in past for high-risk groups

Meningococcal vaccination

- Routine vaccination of adolescents 11-18 yo
  - Single dose at age 11-12 years, with a booster dose at age 16 years for persons who receive the first dose before age 16 years
- Vaccination of persons aged ≥2 months at increased risk for meningococcal disease
  - Who is at increased risk?
    - Adolescents, immune disorders, occupational exposures, travel exposures

Meningococcal vaccination

- Immune "disorders"
  - Anatomical or functional asplenia
  - Complement component deficiency
  - HIV (give 2 doses but not early)

❖ Schedule depends on age when start the series

It's complicated – go to the CDC guidelines, but basically…

Vaccination against meningococcal disease for those with high-risk conditions or at increased risk of disease:

- Anatomic/functional asplenia (including sickle cell disease)
  - If under 19mos: 4 dose infant series of MenHibrix or Menveo at 2, 4, 6, and 12-15 mos
  - If 19-23 mos and not completed primary series of MenHibrix/Menveo: give a 2-dose primary series at least 3 mos apart
  - For children 24+ mos: give a 2-dose primary series of Menactra or Menveo at least 2 mos apart
  - NOTE: Do not give Menactra under 24 mos due to interactions with PCV
- Persistent complement component deficiency:
  - If under 19 mos: 4 dose infant series of MenHibrix or Menveo at 2, 4, 6, and 12-15 mos
  - If 7-23 mos of age, 2 options:
    - Menveo 2-dose series age 7-23 mos, 2nd dose after 12mos of age, and at least 3 mos between doses
    - Menactra 9-23 mos of age, a 2-dose series with doses at least 3 mos apart
    - 24 mos or older, give a 2-dose series of Menveo or Menactra at least 2 mos apart

You have a 5mo patient who has received his 2 and 4 mo vaccinations and was just found to be asplenic. What do you?

A. Give MenHibRix as if he needs a catch-up Hib series

B. Start 4-dose Menveo (MenACYW-CRM) series now

C. Give one MenHibRix (HiBMenCY) at 6mos then 3 more doses of MenACYW-CRM

D. Wait until 9 mos to give Menactra (MCV4-D)

DISEASE/CONDITION SPECIFIC VACCINE INFORMATION

Primary Immunodeficiencies

- This is a huge, heterogenous group
- Recommendations vary based on type of defect, refer to the IDSA guidelines for specifics. These guidelines have many categories of immunodefiencies.
- Safe to give inactivated influenza vaccine (efficacy variable)

Pre-transplant

- Typically check serology for:
  - Hepatitis B, measles, mumps, rubella, varicella
  - Some centers may check Hepatitis A (especially in liver)
- Vaccinate if negative serology
- Catch-up on all recommended vaccines pre-transplant
  - Look at youngest age vaccines are approved for if you need
  - Beware of live-virus vaccines if transplant impending

Cancer chemotherapy/BMT

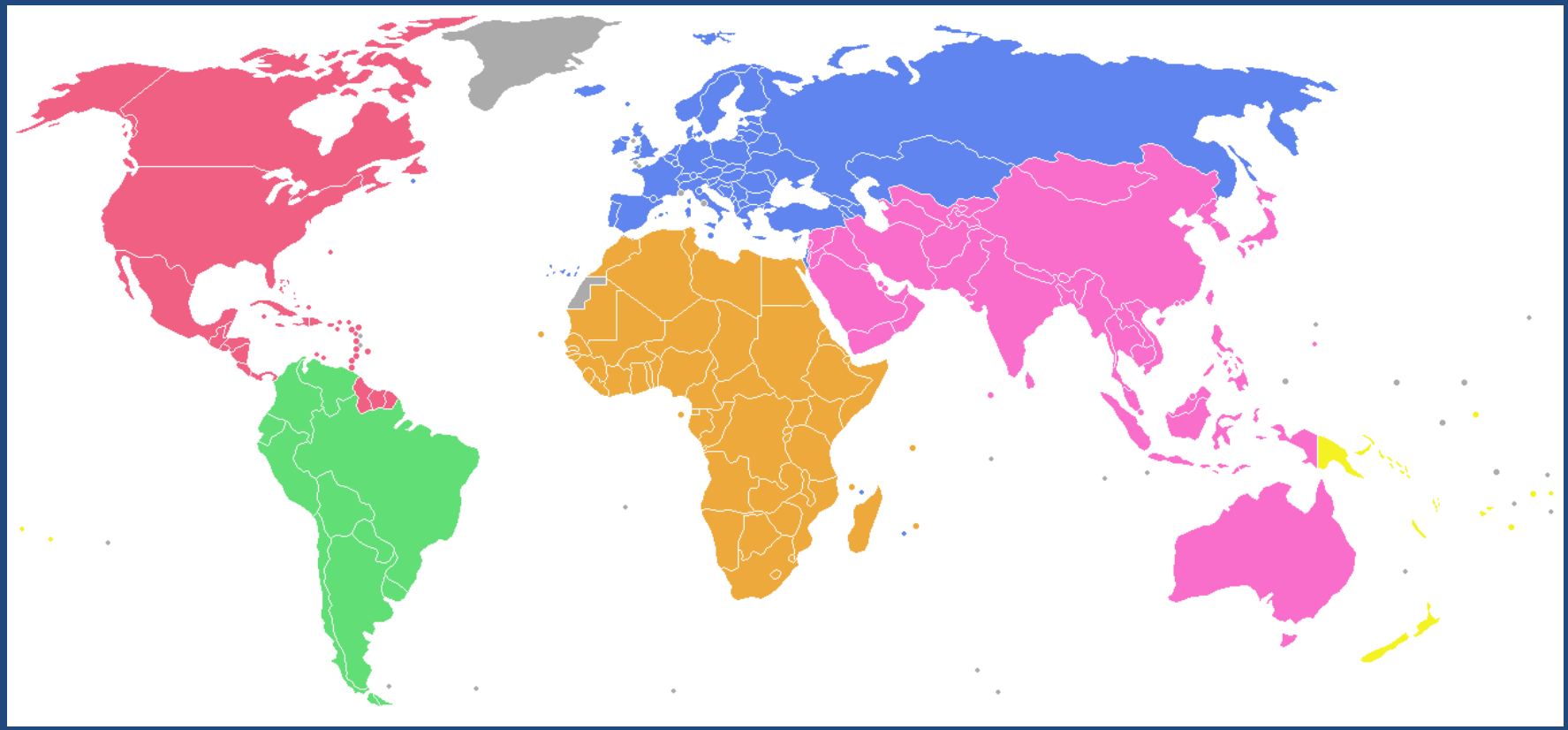
- During cancer treatment, give age-appropriate inactivated vaccines, but do not count them as valid (i.e. revaccinate after treatment is finished)
- Revaccinate according to CDC catch-up schedule unless a protective antibody titer for a specific vaccine is proven
  - Cancer chemo: Can start as early as 3 months after unless received anti-B cell therapy then start at least 6 months after therapy
  - BMT: Variable, based on immunosuppression and GVH
    - Inactivated starting as soon as 6 mos post-BMT
    - Live-virus starting at least 24 most post-BMT

Why do asplenic/hyposplenic people have difficulty with encapsulated bacteria?

A. Marginal zone B cells reside mainly in the spleen
B. Spleen is necessary to clear antibody-coated bacteria from circulation
C. 25%+ of WBCs reside in the spleen
D. A and B
E. None of the above

Asplenia

- If you know ahead of time that someone will lose his/her spleen, vaccinate with meningococcal and pneumococcal vaccines
- Groups who could be asplenic (anatomic or functional)
  - Surgical (many reasons)
  - Congenital heart disease including polysplenia
  - Sickle cell disease, Thalassemia major, lymphoproliferative diseases
  - Significant radiation during chemotherapy/BMT
  - Autoimmune diseases: IBD, celiac (functional, not sure this is predictable)



TRAVEL CONSIDERATIONS

What is the most common cause of fever in the returning traveler where the pathogen is identified?

A. Dengue
B. Malaria
C. Typhoid
D. Influenza
E. EBV and other viruses causing mono-like symptoms
F. Rickettsial disease

Which of the following are infections that can be more severe in people on anti-TNF-alpha medications AND are travel-related?

A. Endemic fungi (histoplasmosis, coccidioidomycosis, blastomycosis)
B. Tuberculosis
C. Hepatitis B
D. Viral URI
E. All of the above

Travel for immunocompromised

- Recommend that they go to a travel clinic
- There are many other considerations, food safety is probably the biggest issue
- But, with regard to vaccines….

Live Travel Vaccines

- Not Recommended:
  - BCG
- These have Inactivated alternatives:
  - LAIV
  - Japanese encephalitis (not licensed in US anyway)
  - Polio (OPV)
  - Oral Typhoid
- Generally not recommended if immunocompromised, but you should consider risk/benefit ratio in relation to potential exposure and level of immunosuppression. Considered safe in HIV+ with CD4≥200 or ≥15%.
  - MMR
  - Yellow Fever

CDC, WHO

Inactivated Travel Vaccines

- No health contraindication, but remember that they may not be as protective and you should educate patients about this

- Depending on destination, type of activity, duration of travel, and host, the following could be considered:
  - Cholera, TdaP, Hep A, Hep B, Influenza, Japanese encephalitis, Meningococcal, Polio (IPV), Rabies, Tick-born encephalitis, Typhoid (injectable)

CDC, WHO

Summary

- Immunocompromised children:
  - Have decreased responses to vaccines
  - Have faster waning immunity to vaccines
- Strep pneumo and meningococcal vaccines have specific indications for high-risk groups
- Live vaccines are contraindicated in many immunocompromised groups, but not all

On the Horizon….

- Inactivated varicella vaccine (in Phase III)
- CMV vaccine
- Expanded use of:
  - High-dose influenza vaccine, double-dose Hepatitis B, Zostavax
  - Booster doses
  - Live-virus vaccines