Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

Meningococcal Disease

science & technology in action
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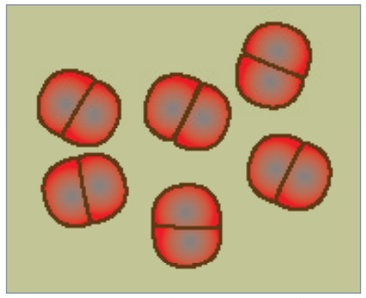
11th edition

Meningitis is an inflammation of the ***meninges***, three layers of tissue that surround and protect the brain and spinal cord. The classical symptoms of meningitis are fever and vomiting, drowsiness, feeling confused and irritable, ***photophobia*** (sensitivity to light) and stiff neck. The final two symptoms are often absent in small children.



Typical appearance of diplococcal bacteria such as *Neisseria meningitidis*

Types

There are three main causal micro-organisms of meningitis; viruses, bacteria and, very rarely, fungi.

Viral meningitis, also known as "aseptic meningitis", is the commonest type of meningitis and is most frequently seen in children. It is a milder disease than bacterial meningitis and is rarely fatal, with a mortality rate of less than 1 in 100. People with viral meningitis may have severe symptoms but they usually recover completely. There is no specific drug treatment for viral meningitis. Antibiotics are of no value in treating viral diseases as they have no effect on viruses.

Fungal meningitis is very rare. It is generally caused by yeast type fungi such as *Candida albicans,* the cause of ***thrush***. It normally only occurs in people with a ***compromised immune system,*** e.g. in people who are on chemotherapy. We will therefore focus on bacterial meningitis, particularly that caused by meningococcal bacteria.

Bacterial meningitis is caused by a variety of bacteria; for example pneumococcal meningitis is caused by *Streptococcus pneumoniae* and Hib meningitis is caused by *Haemophilus influenzae* type b. However we will focus on meningococcal meningitis, as it is the most common form of bacterial meningitis, which is caused by the gram negative ***diplococcus Neisseria meningitidis***. This is by far the most dangerous form of the disease because it can progress very quickly and cause serious harm or even death in a matter of hours.

Effects

N meningitidis is part of the normal ***non-pathogenic flora*** of the nasal and throat regions of 5-15% of adults, but it is at its most frequent in college students where up to 25% may be ***carriers***. Very occasionally the bacteria can find its way to other parts of the body, such as the meninges, or blood and cause a harmful infection. *N. meningitidis* is only found in humans because humans provide a suitable source of the iron it requires for its metabolism. It is spread by respiratory droplets, which are most efficiently generated by coughing, sneezing and mouth kissing.

Tumbler test for non-blanching rash

The disease can present as meningitis or septicaemia or both. What makes this bacterial disease so dangerous is that it can very quickly develop into ***meningococcal septicaemia,*** or blood poisoning, which is a whole body infection that can lead to ***septic shock***. Septic shock is an ***immune response*** which can lead to low blood pressure, resulting in poor organ function and major tissue damage. Some of the symptoms of septicaemia are different from meningitis. In septicaemia the main symptoms are fever and vomiting, cold hands and feet, fast breathing and painful joints and muscles as well as a ***non-blanching purpuric rash***.

When the bacteria enter the bloodstream, they release ***endotoxins***, which damage the blood vessels' walls causing blood to leak from the vessels into the surrounding tissue. If a blood vessel is under the skin the leaked blood can appear as a very variable purpuric rash (purple rash). The rash can vary from pinhead size, to bruises, or even in severe cases blood blisters. The rash is recognised by its purple colour and more importantly by the fact that it does not blanch, i.e. it does not lose its colour when pressed firmly with a glass. If this type of rash is discovered it is essential that immediate emergency medical treatment is sought.

Meningococcal meningitis symptoms

Meningococcal meningitis can be difficult to diagnose because its most common symptoms – fever, headache, and muscle pain – may be similar to those of influenza (flu). The symptoms of meningitis can occur suddenly and include:

- Headache
- Fever
- Stiff neck or other muscle pain
- Nausea and vomiting
- Photophobia
- Confusion
- Purpuric rash
- Seizures

If meningitis is suspected then seek medical attention immediately. Speed is essential in treating this potentially fatal disease.

Meningococcal disease spreads just like the flu, passing from person to person through everyday activities. Many people carrying the bacteria never become ill but they can pass the bacteria to others without knowing.

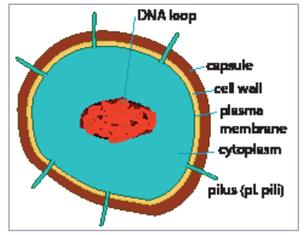
Children under 5 years of age, especially those under one, and teenagers between 15-19 years are most commonly affected. In Ireland the disease is most frequent in winter and early spring. Students attending college for the first time are at a higher than normal risk of contracting the disease due to increased exposure to the disease, and their close-quarter lifestyle.

Ireland has the highest rate of meningococcal disease in Europe. It is a frightening statistic that 1 in 15 people who develop meningococcal septicaemia will die, and 1 in 10 of those who survive will suffer serious long term consequences, such as loss of digits or limbs, nervous system damage and deafness.

Treatment and prevention

If meningococcal meningitis is suspected ***antibiotics*** will be administered immediately to check the spread of the disease and every minute is important to reduce the severity of any damage. Early intervention usually results in a full recovery.

'Prevention is better than a cure' is a frequently stated maxim and in this case it certainly applies.



Typical prokaryotic cell structure

Although *N meningitidis* is one species there are five different ***serotypes*** (strains); A, B, C, W135, X, and Y. These vary in abundance in different parts of the world. Serotypes B and C are the most common in Ireland. A vaccine for serotype C (MenC) was introduced in Ireland in 2000. The vaccine proved very effective as 90% of those vaccinated become immune. As a result of the ***immunisation programme*** there has been a 98% drop in reported cases of type C meningococcal disease since 2000. MenC vaccine is now routinely given to children at four months, and then thirteen months, and a final vaccine is given at 12-13 years of age. This booster dose was added to the school immunisation programme in 2014. There is a new vaccine available for serotype B (MenB) which was introduced into the childhood immunisation schedule in the UK in September 2015. This vaccine has not yet been introduced in Ireland.

Antibiotics and/or vaccines are given to close contacts of patients with meningitis as a prophylactic measure to prevent them contracting the disease.

Olivia Giles

"I may have lost my feet and hands, but I really do feel lucky."

In 2002, at the age of 36 lawyer Olivia Giles contracted meningococcal septicaemia. In order to save her life doctors had to amputate her hands and her feet.

She now runs a charity, called '500 miles', that supplies prosthetic limbs to disabled people, especially in Africa.

Biology

Bacteria are ***prokaryotic*** micro-organisms i.e. they do not have a membrane bound nucleus or membrane bound ***organelles*** such as ***mitochondria***. In the case of *N. meningitides* it uses cytoplasmic extensions called ***pili*** to stick to its host and its ***capsule*** prevents attack by ***phagocytic white blood cells.*** It is not stained by Gram's stain so it is described as a ***gram negative*** bacterium.

In an attempt to positively identify the causative organism a sample of sterile cerebrospinal fluid can be ***cultured*** on chocolate ***agar***, which is made from ***lysed*** blood cells and is named due to its dark chocolate-brown colour. It does not contain any chocolate. Cultures are very slow to incubate, taking up to a week. They often do not give a positive result because the routine and immediate administration of antibiotics when the disease is suspected reduces the quantity of bacteria present, or because incorrect transport conditions kill the delicate bacteria. More modern non-culture methods of identification are now available, using ***PCR*** (Polymerase Chain Reaction) to amplify and then analyse the DNA from a tiny sample; as a result positive identification can be obtained within 24-48 hours.

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The National Immunisation Office (NIO) is a coordinating unit within the Health and Wellbeing Division of the Health Service Executive (HSE). The National Immunisation Office is entirely government funded and receives no funding from any external commercial source.

The NIO is responsible for the coordination of immunisation programmes, for managing vaccine procurement and distribution and for developing training and communication materials for health professionals and the general public including the national immunisation website www.immunisation.ie

All information on the website, developed originally from the Immunisation Guidelines for Ireland, is evidence based and reviewed by a panel of immunisation experts to ensure it is scientifically accurate. The site content is monitored and regularly updated by a team of public health doctors who are members of the National Immunisation Advisory Committee (NIAC) of the Royal College of Physicians in Ireland. This committee makes recommendations on vaccination policy in line with international best practice and based on how common the diseases are in Ireland.

NIAC guidance is regularly updated and the latest updates are available to download from http://www.hse.ie/portal/eng/health/immunisation/hcpinfo/guidelines/immunisationguidelines.html

Information leaflets for parents can be downloaded from www.immunisation.ie or can be ordered from www.healthinfo.ie or from local health offices.

For further information see:
www.immunisation.ie

www.hpsc.ie

https://www.rcpi.ie/article.php?locID=1.10.237

Find this and other lessons on www.sta.ie

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Syllabus references

The main syllabus references for the lesson are:

Leaving Certificate Biology

- Ecological Relationships Parasitism (p. 12)
- Organism Adaptations Note an adaptation feature by any organism in the selected ecosystem. (p. 14)
- Diversity of Organisms (p. 29): Micro-organisms. Understanding of the term "pathogenic". Definition and role of "antibiotics". Monera, e.g. Bacteria. Bacterial cells: three main types. Fungi
- Responses in the Human. Phagocytic white blood cells. Specific defence system: antigen antibody response. Definition of "induced immunity". Vaccination and Immunisation. (p. 39)

Science and Technology in Action is also widely used by **Transition Year** classes.

Learning Outcomes

On completion of this lesson, students should be able to:

- describe the symptoms of meningitis and septicaemia, the difference between them and the action required if the disease is suspected
- name the different types of micro-organism that can cause meningitis
- outline how species of micro-organisms that are non-pathogenic in one part of the body can be pathogenic in another part
- describe how specific vaccines can prevent meningococcal disease
- outline the dangers of meningococcal septicaemia and the importance of quick and decisive action.

General Learning Points

These are additional relevant points which are used to extend knowledge and facilitate discussion.

- Vaccination is an effective way of preventing most, but not all, vaccine preventable diseases.
- Culturing micro-organisms is not always the quickest and best way of identifying a disease.
- PCR and electrophoresis provide a quicker way of identifying infective micro-organisms such as *N. meningitidis*.
- Bacteria are prokaryotic micro-organisms as they do not have a membrane bound nucleus or membrane bound organelles.
- Bacteria can be classified by the effect of Gram staining and also by their shape.

Student Activities

1. Find out what component of the bacteria is used to produce the vaccine and how it works. Try to discover what other substances are included in the vaccine and what the purpose of each substance is.
2. Find the frequency of the different serotypes of *N. meningitidis* in different parts of the world.
3. Is vaccination against *N. meningitidis* advisable before travelling to certain parts of the world? Why.
4. Investigate the culturing of *N. meningitidis* in the laboratory and explain why laboratory workers should be vaccinated even though they use aseptic techniques in their work.
5. Find out more about viral and bacterial meningitis, and the micro-organisms responsible for causing the infections.
6. Find out the other diseases that new-born children are vaccinated against.
7. Investigate the ways that bacteria are classified by staining and by shape.
8. (Group activity) College students have a greater risk of bacterial meningitis infection than the general population. Investigate why this is so. Design a poster for college students to raise awareness of the disease. The poster should include the symptoms of the disease, advice on what to do if meningitis is suspected and a list of relevant phone numbers of medical facilities.

True/False Questions

a) Meningitis is inflammation of the membranes surrounding the central nervous system. **T F**

b) Viral meningitis is normally more serious than bacterial meningitis. T F

c) Meningococcal disease is only contracted by physical contact. T F

d) Only children contract meningococcal disease. T F

e) There is an effective vaccine for meningococcal B disease. T F

f) The vaccine against meningococcal C disease is very safe and effective. T F

g) The MenC vaccine protects against all other forms of the disease. T F

h) Anti-viral drugs cure meningococcal disease. T F

i) The rash associated with meningococcal disease does not disappear when a glass is held against it. **T F**

j) If you suspect meningococcal disease you should seek emergency medical help. **T F**

Check your answers to these questions on www.sta.ie.

Examination Questions

Leaving Certificate Biology (HL) 2005, Q. 15 b

i. Draw and label a diagram to show the basic structure of a typical bacterial cell.

ii. Other than being prokaryotic, state two ways in which a typical bacterial cell differs from a typical human cell (e.g. cell from cheek lining).

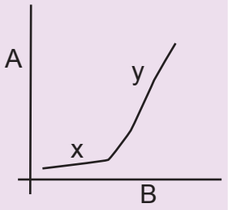
iii. Describe how some bacteria respond in order to survive when environmental conditions become unfavourable.

iv. What is meant when a bacterium is described as being pathogenic?

v. What are antibiotics? Use your knowledge of the Theory of Natural Selection to explain the possible danger involved in the misuse of antibiotics.

Leaving Certificate Biology (HL) 2008, Q.15.c

The diagram shows a bacterial growth curve.



i. A and B represent the labels on the axes. What does each of them stand for?

ii. What term is applied to the part of the curve labelled x? What is happening during x?

iii. What term is applied to the part of the curve labelled y? What is happening during y?

iv. Copy the diagram into your answer book and continue the curve to show the next phase. Explain why you have continued the curve in this way.

v. Distinguish between batch and continuous flow food processing using micro-organisms in the food industry.

Leaving Certificate Biology (HL) 2010, Q.15.c

Suggest a biological explanation for each of the following observations:

Doctors are reluctant to prescribe antibiotics to patients suffering from common cold-like symptoms.

Leaving Certificate Biology (HL) 2013, Q. 12 b

i. Name the kingdom to which bacteria belong.

ii. Draw a large diagram of a bacterial cell to show:

1. The relative positions of the cell wall, cell membrane and capsule.

2. A plasmid.

Label each of the above structures.

Did You Know?

- The HSE has detailed information on Meningococcal disease on its website. This includes information on how it is contracted, identified, and treated. It also has details of the vaccination programme for its prevention.
- In 2014 there were 82 cases of invasive meningococcal disease notified in Ireland. Although this represented an increase on previous years (66 cases in 2012) the overall trend has been downward. In 1999 there were 536 cases.
- Since the MenC vaccine was introduced in October 2000, there has been a dramatic decline in the number of bacterial meningitis cases occurring each year. Nevertheless, it is important that parents are ever vigilant to the signs and symptoms of meningococcal disease.

Biographical Notes

Hans Christian Gram, 1853 – 1938

Hans Christian Gram was a Danish doctor and bacteriologist who, in 1882, while professor of medicine at Copenhagen University, developed a staining technique to make the structures of bacteria easier to see. The stain, which is named after him, has crystal violet as its main ingredient and involves a counter stain of safranin.

Bacteria that stain purple are classified as 'Gram positive' and those that stain red with the counter stain are classified as 'Gram negative'. Even now, almost 130 years later, this is nearly always the first test used on the path to identifying a bacterium as it enables bacteria to be split into two groups quite quickly.

Revise The Terms

Can you recall the meaning of the following terms?
Revising terminology is a powerful aid to recall and retention.

agar, antibiotics, antigens, antibodies, capsule, compromised immune system, cultured, diplococcal, endotoxins, Gram negative, immune response, immunisation programme, meninges, meningitis, non-blanching, non-pathogenic flora, PCR (polymerase chain reaction), phagocytic white blood cells, photophobia, pili, prokaryotic, prophylactic, purpuric rash, septic shock, serotype C, spherical, vaccine

Check the Glossary of terms for this lesson on www.sta.ie