Microbes, Transmission Routes and Survival Outside the Body

3

Abstract

Microbes like bacteria, virus, parasites and fungi may naturally colonize skin and mucous membranes without any sign of illness, for a longer or shorter period, in all humans, animals, fish, parasites, plants and all other living beings. Some types may be more invasive in human tissue than others. Many microbes are free-living in the environment—in water, soil and air and on equipment—as a part of the normal microbial flora on the Earth. Most of them are not dangerous and live in peaceful symbiosis with other living beings and may also be transferred between living species, from man to animal or man to plants and environment—and vice versa. New and old human pathogenic microbes are increasing all over the world. Some agents, like drug-resistant bacteria and highly pathogenic viruses, are more dangerous than others, and some microbes may cause chronic devastating diseases. Transmission routes depend on the robustness of the microbe in the environment, virulence, infectious dose, anatomical site in the body, etc. Pathogenic microbes are spread by contact, air, water, food, beverages, contaminated equipment and environment and are more seldom vector-borne, by insects or animals. The following chapter is focused on the most frequent pathogenic microbes, their preselected localization in the body, transmission routes and survival in the environment.

Keywords

Microbes · Pathogenic microbes · Virulence · Predilection · Biological material · Anatomical site · Environment · Survival · Transmission · Spread of infection

3.1 Microbes are Mostly Normal, Nonpathogenic Flora

Microbes like bacteria, virus, parasites and fungi may naturally colonize skin and mucous membranes without any sign of illness, for a longer or shorter period, in all humans, animals, parasites, plants and all other living being [1–6]. Some types may

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be more invasive in human tissue than others, partly via mucous membranes and lesions in the skin.

Many microbes are free-living in the environment—in water, soil and air and on equipment—as a part of the normal microbial flora on the Earth. Most of them are not dangerous and live in peaceful symbiosis with other living beings and may also be transferred between living species, from man to animal or man to plants and environment—and vice versa [1–6]. Microbes, like bacteria, may outnumber us by a factor of 10^{22}, are heavier than us by a factor of 10^{8}, have existed on Earth more than 1000 times longer than us and may undergo 500,000 generations in just one of our generations [7].

The existence of humans and animals is dependent on a rich and active bacterial flora in the gut, participating in the decomposition of food substances to energy and growth. Large amounts of bacteria in the gut (1–2 kg) and on the skin is a normal condition. Humans are releasing microbes into the environment and air wherever they move and—at the same time—are picking up new microbes from the environment.

3.2 Pathogenic Microbes: New and Old

Pathogenic microbes cause illness in most humans if introduced into sterile tissue. "Opportunistic" microbes may cause problems in people with reduced immune defence and/or if large amounts are introduced in sterile tissue. Nonpathogenic microbes nearly never cause illness in humans [1–3]. Human pathogenic microbes often survive for a long time outside the body—in the environment [1–6]. Therefore, they are special threats to patients, personnel and visitors in healthcare institutions where there often is an accumulation of infectious diseases.

New and old human pathogenic microbes are increasing all over the world. Some agents, like drug-resistant bacteria (methicillin-resistant *Staphylococcus aureus*, MRSA, multidrug-resistant tubercle bacilli and others) and highly pathogenic viruses (Ebola, SARS and others), are more dangerous than others. Other viral agents may cause chronic devastating diseases like HIV and hepatitis B and C.

Microbes may have preselected locations and tissues in the host, like influenza virus, pneumococci and tuberculosis mostly in lungs, hepatitis viruses in the liver and blood, *Clostridium difficile* and norovirus in the gut, coagulase negative staphylococci on the skin, etc.

3.3 Transmission Routes: Spread of Infection

The transmission routes of microbes are many and different and depend on the robustness of the microbe in the environment, climate and temperature, virulence, infectious dose, etc. Pathogenic microbes are spread by contact, air, water, food, beverages, contaminated equipment and environment and are more seldom vector-borne, by insects or animals. Drug-resistant microbes and/or resistance genes are

common on the global food market for humans, animals and fish [8–11]. In addition, increased mobility, climatic changes, overcrowding, war and disasters, poor hygiene and poor infection control are increasing the transmission rate. Prudent use of antimicrobial drugs, proper hygiene and good infection control for humans, animals and fish are essential for stopping spread of infections [12–19].

Microbes: pathways and survival outside the body—in environment

Biological material—location/microbes	Transmission routes	Lifetime in the environment[1]
Wound		
Staphylococcus aureus	C/A [2]	3–10 months
Methicillin-resistant *S. aureus* (MRSA)	C/A	3–10 months
Gram-negative rods (*Escherichia coli*, *Klebsiella*, *Enterobacter*, *Serratia*, *Proteus*, *Pseudomonas*, *Acinetobacter*, etc.)	C/(A)	2 days–16 months
Multidrug-resistant gram-negative rods	C/A	2 days–16 months
– ESBL: *E. coli*, *Enterobacter*, *Citrobacter*, *Klebsiella*, *Serratia*, etc.		
– Others: *Pseudomonas*, *Acinetobacter*, *Stenotrophomonas maltophilia* – New multidrug-resistant with NDM-1 gene; resistant to carbapenem and most other antibiotics		*Klebsiella* > 2.5 years
Enterococci, including VRE	C	2 months–4 years
Groups A, B, C, G streptococci	C	1–7 months
Prosthesis, foreign body		
Coagulase-negative staphylococci	C/A	3 months
S. aureus and MRSA	C/A	3–10 months
Gram-negative rods	C	2 days–16 months
Enterococci, including VRE	C	2 months–4 years
Candida	C	Several months
Blood and tissue fluids		
Hepatitis A, B, C, D, E	B (C) [3]	3 days–year
HIV	B (C) [3]	3–14 days
Other retroviruses (HTLV-I, HTLV-II)	B	Days
Parvovirus B19 and others	B	> 1 year
Cytomegalovirus	B/C	Hours to days
Prions	B [4]	Infinite?
Malaria and other blood parasites	B, insects	Varies
Yellow fever virus	B, mosquito	Varies
Haemorrhagic fever virus	B/C/A, insects	Varies—long?
Respiratory tract infections		
Pneumococci, including penicillin resistant	C/A	Hours–20 d
Gram-negative rod bacteria (*E coli*, *Klebsiella*, *Enterobacter*, *Acinetobacter*, *Serratia*, *Pseudomonas*, *Morganella*, etc.)	C/A	2 days–16 months
Haemophilus influenzae	C/A	Hours–12 days
S. aureus	C/A	3–10 months

(continued)

Biological material—location/microbes	Transmission routes	Lifetime in the environment[1]
Chlamydia pneumoniae/Mycoplasma pneumoniae	C/A L	Hours–days
Legionella pneumophila, etc.	A/C/water	Water: infinity
Mycobacterium tuberculosis (tuberculosis)	C/A	1 year
Neisseria meningitidis; meningococcus	C/A	Hours
Pertussis; *Bordetella pertussis*	C/A	3–5 days
Influenza viruses A, B, parainfluenza, adeno, rhino, entero, corona	C/A	Hours–20 d
RSV (respiratory syncytial virus)	C/A	Hours–3 d
Metapneumovirus	C/A	Unknown
Coronavirus OC43 (cold virus) Human bocavirus (*Parvoviridae*)	C/A	Unknown
Avian influenza	A/C/B	Days to 6 weeks
SARS, MERS	A/C/B	3–4 weeks
Haemorrhagic fever virus	A/C/B	Varies prolong
Faeces/gastrointestinal tract		
Intestinal pathogenic bacteria (*Salmonella*, *Shigella*, *Campylobacter*, *Yersinia*, Enteropathogenic *E. coli*, *Helicobacter*, *Vibrio cholerae*)	C/food/water	4–14 days–4.2 years
Clostridium difficile (spores)	C	Years
Listeria monocytogenes	C/food/water	Long, chilled
Bacterial toxins (*E coli*, *S. aureus*, *Clostridium perfringens*, *Salmonella*, etc.)	C/food	Hours to days
Rota/adeno/norovirus (Norwalk)	C/food/water	60–90 days
Hepatitis A, hepatitis E	C/food/water	14 days–2 months
SARS, MERS and avian influenza virus	C/A/B	3–6 weeks
Parasites *Giardia lamblia*, *Cryptosporidium parvum*, *Entamoeba histolytica*, schistosomiasis, *Ascaris*, hookworm, trichuriasis, strongyloidiasis, etc.	C/water/food	Weeks–months–year
Urinary tract infections		
E. coli	C	Hours–16 months
Other gram-negative rods (*Proteus*, *Klebsiella*, *Citrobacter*, *Enterobacter*, *Pseudomonas*, etc.)	C	Hours to 16 months
Enterococci	C	2mndr–4 years
Resistant bacteria (VRE, ESBL, CRE, MRSA, etc.)	C/A	days–4 years
Others		
Borrelia burgdorferi, *Ehrlichia* sp. and less frequent bacteria	Ticks/insects, etc.	Varies
Varicella zoster virus	A/C	Hours–days
Herpes simplex virus	C	Hours–2 months
(Measles, rubella, parotitis virus)	A/C	Hours–days
Highly pathogenic microbes		
Multidrug-resistant *Mycobacterium tuberculosis*	A/C	1 year

Biological material—location/microbes	Transmission routes	Lifetime in the environment[1]
SARS, MERS virus	A/C/B	2–6 weeks ++
Haemorrhagic fever virus	A/C/B	2–3 weeks
(Lassa, Ebola, Sabia, Marburg virus, etc.)	A/C/B	Weeks
Avian influenza	A/C/B	Days–6 weeks ++

From Refs. [1–6]

1. Lifetime in the environment, outside the body. Most gram-negative rod bacteria live almost infinite in water; some also multiply rapidly in water (*Klebsiella*, *Enterobacter*, *Pseudomonas*, *Proteus*, etc.).
2. C = contact transmission, A = airborne transmission (including droplets), B = blood-borne infection, v = variable, k = short life outside the body, ++ can be long life in optimal environment.
3. May be transmitted by mucous membrane contact, especially lesions of the mucosa.
4. Infectious protein molecules; spongiform encephalopathy.

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