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Mini Review

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Bacteriophages for Detection and Control Pathogens

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ABSTRACT

Bacteriophages are viruses infecting bacteria; they are obligate intracellular parasites also require their own metabolism. Phages are excessively host-specific, capable only to infect certain classifications or even strains. Following their detection beginning in the 20th century, phages were expansively applied to treat diverse bacterial disorders in people and animals. At present, as the problem of antibiotic resistance serves ever more severe, several scientists also clinicians are observing again at bacteriophages as a therapeutic choice in the treatment of bacterial infections. The aim of this review is to consider the current evidence on the effects of bacteriophages for detection and control pathogens.

Key words: Phage therapy, biocontrol, Bacteriophage

1. INTRODUCTION

Viruses are small infectious particles; definitely 20-200 nm consisting of a nucleic acid core (single or double stranded RNA or DNA) covered by a protein coat (capsid) and in some cases a lipid envelope. Bacteriophages (phages) are viruses that infect prokaryotes (1). With today`s emphasis on the availability of fresh foods without chemical preservatives, there is a require for new preservation approaches. Bacteriophages or phages are the headmost numerous microorganisms in our environs also are existent in high numbers in water as well as foods of various origins (2, 3). They are cultured in their respective host bacteria using conventional microbiological methods and definitely have very certain host ranges limited to one or a few bacterial species. Phages have been applied in a diversity of applications to exploit their exquisite host specificity, including use as indicators of the presence of their bacterial hosts and as indicators of bacterial (manure) contamination. Typing phages have been broadly practiced in identifying also categorizing human bacterial pathogens. Phages allow potential for targeted biological manage of bacterial pathogens in human, animal, as well as plant diseases (4, 5). Phages were discovered in 1915 by British microbiologist Felix Twort, and, independently in 1917, by French-Canadian microbiologist Felix d'Hérelle (6). Phages can be conventionally classified into two categories according to the strategies they apply to get away their hosts: filamentous phages and lytic phages. Filamentous phages always extrude from their hosts without effecting host lysis, whereas entirety difference phages are lytic phages that encode gene products to compromise or destroy the bacterial cell wall (7-9). The aim of this review is to consider the current evidence on the effects of bacteriophages for detection and control pathogens.

2. Properties of Phages

Double classes of bacteriophages are recognised; temperate as well as virulent. In the course of lytic infection, virulent phages inject their nucleic acid into the host cell resulting bond. Expression of the phage genome directs the cellular machinery of the host to synthesise new phage capsule material. The resulting phage progeny is eased by fatal cell lysis enabling the lytic cycle to maintain as new cells are infected (Figure 1). Stress conditions such as ultraviolet light or chemical mutagens can induce a switch to the lytic cycle. In contrast, all along lysogenic infection moderate phage nucleic acid recombines with the host cell genome creating a dormant prophage. The prophage is reproduced in the host cell line and confers immunity from infection by the same type of phage (10-12).

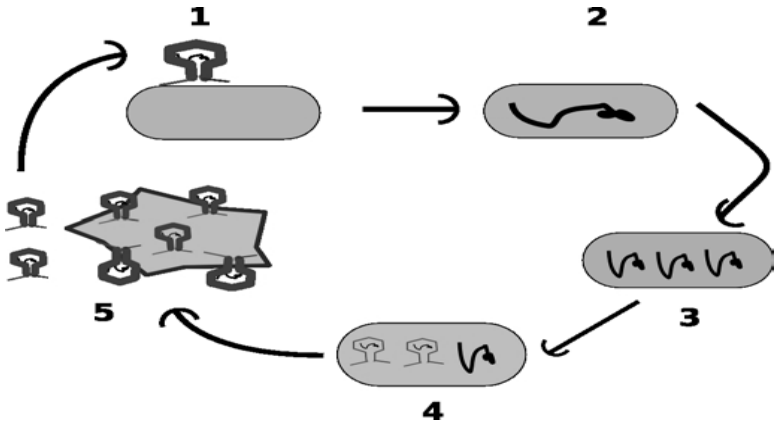

Figure 1. Bacteriophage life cycle

1: bacteriophage attaches to a specific host bacterium. 2: it injects its DNA. 3: bacteriophage uses bacterial DNA and protein synthesis machinery to make the different bacteriophage parts. 4: Assembly of new bacteriophage. 5: The new bacteriophages are released after cell lysis so that new cycles can begin again.

2.1. Problems of phage therapy

- Host range
- Bacterial residues display in the phage compositions
- Actions to extract host bacteria from therapeutic Preparations
- Rapid clearance of phages
- Lysogeny
- Anti-phage antibodies
- Failure to establish scientific proof of efficacy
- The scientific style of phage investigators in the historical era (6).

2.2. Advantages of Phages

- They are self-replicating however additionally self-limiting due to they multiply only while sensitive bacteria are exhibit.
- They can be targeted far more specifically than most antibiotics to the problem bacteria, affecting much less ruin to the normal microbial equal in the gut.
- Phages can common be targeted to receptors on the bacterial surfaces that are included in pathogenesis, so any resistant mutants are attenuated in virulence.
- Few side effects have been reported for phage therapy.
- Phage therapy would be particularly useful for people with allergies to antibiotics.
- Beneficially chosen phages can facilely be used prophylactically to aid control bacterial disorder at dates of exposure or to clean hospitals additionally aid defend adversarial hospital-acquired (nosocomial) infections.
- Especially for external applications, phages can be prepared fairly inexpensively and regionally, simplifying their potential applications to underserved populations.
- Phages can be applied either separately or in conjunction with foreign antibiotics to help reduce the development of bacterial resistance (6, 13).

3. Bacteriophages for Phage typing

Phage typing is a popular instrument to specialize bacterial isolates, and is applied in epidemiological examines with the plan of determining and improvising outbreak-associated strains. Although more sophisticated systems for differentiation are available, such as ribotyping, accidental advanced polymorphic DNA-PCR fingerprinting, or pulsed field gel electrophoresis of enzyme-digested DNA, the adaptable sensitivity to a set of bacteriophages (phage typing) remains a useful method because of its speed, relative simplicity, and cost-effectiveness. Studies on enterohemorrhagic *E. coli* (EHEC) and Campylobacter showed that phage typing can be highly beneficial, definitely because any one typing technique alone fails to create all the relevant data concerning epidemiological relatedness (14, 15).

4. Bacteriophages for control of Pathogens

Phage remedy is the therapeutic apply of lytic bacteriophages to treat pathogenic bacterial infections. Phages were applied expansively in the beginning 20th century to treat human additionally animal illness with varying degrees of success (16). Before attempting phage therapy several, sometimes rather demanding, prerequisites should be met:

1. Phage therapy should not be assayed priority the biology of the therapeutic phage is well accepted. Since the phage–host systems are drastically confused, this essential has to be faced with some common sense.
2. Phage preparations should meet all the safety requirements; the preparations should be free of bacteria and their components.
3. Phage preparations should contain infective phage particles, thus storage of the preparations should be validated.
4. The phage receptor should be known. In a bacterial population of 106–108 bacteria there is a high probability

of spontaneous phage-resistant mutants lacking in the receptor or with a changed receptor. It can be believed that a mutation deleting the receptor that acts as a virulence factor of a pathogen (such as LPS) would attenuate the bacterium and then it would be easier for the host immune system to eliminate the bacteria.

5. The efficacy of phage therapy should be tested in an animal model. Each phage may behave differently *in vivo* (17). Wommack and Colwell, summarised studies concluding that accrual of focused viral particles tended to deplete bacterial populations by 20-40 % (18). Schuch *et al*, described on the separation of a phage enzyme able of lysing the biological warfare bacterium, *Bacillus anthracis* (19).

4.1. Bacteriophage treatment of E. coli

Escherichia coli is the factor of a third of cases of childhood diarrhoea in expanding and threshold countries and is also the most prominent cause of diarrhoea in travellers to developing countries (20). *E. coli* O157:H7 is a highly virulent foodborne pathogen naturally detected in the gastrointestinal tract of ruminants also difference mammals. *E. coli* phages are normally separated from sewage, hospital waste water, polluted rivers as well as faecal samples of humans or animals (10). Merril *et al*, demonstrated in 1996 that mice with fulminant *E. coli* bacteremia could be rescued by phages (21). Raya et al, manifested that a single oral dose of bacteriophage definite to *E. coli* O157:H7 assigned to sheep impended in a two-log reduction (% 99) of the pathogen (22).

4.2. Bacteriophage treatment of Listeriamonocytogenes

Listeria monocytogenes has only lately appeared as a serious food-borne pathogen that can act abortion in pregnant women as well as meningitis, encephalitis also septicaemia in *newborn* infants and immunocompromised adults (23). Pasternack and Sulakvelidze, patented six *Listeria monocytogenes* phage strains (ATCC Deposit Accession Nos. PTA-5372, PTA-5373, PTA-5374, PTA-5375, PTA-5376 and PTA-5377), which are capable of con-trolling the contamination of food products by *L. monocytogenes* (24). In study, Carlton et al, which also measured in vivo nourishing toxicity also addressed the issue of potential allergenicity by an in silico coming, the consequence of the broad host extent, virulent phage P100 on spreading of Listeria in soft cheese was studied. Complete eradication of target cells was achieved, depending on dosage and treatment schedule (25).

4.3. Bacteriophage treatment of Campylobacter

Campylobacter is an important human pathogen and is the most common cause of bacterial gastroenteritis worldwide. *Campylobacter jejuni* and *Campylobacter coli* are major causes of acute bacterial enteritis in the developed world. Household poultry have been determined as the primary repository for these organisms also their existence in undercooked poultry is complained as the natural source of human infection. In study wagenaar *et al*, conclude that phage treatment is a promising alternative for lessening *C. jejuni* colonization in broilers (26). Goode et al. Goode et al. were capable to obtain a 95% reduction in *C. jejuni* counts on artificially (27).

4.4. Bacteriophage treatment of Salmonella

Salmonella is a Gram-negative bacterium. Its cell envelope includes a lipopolysaccharide (LPS) layer (the outer membrane), which can defends it from the lysis enforced by lytic enzymes. Phage biocontrol calculates have been described either in vivo also on food. Goode *et al*, observed eradication of phage-susceptible Salmonella strains (27). Whichard *et al*, tested the broad host range Salmonella phage Felix-O1 in biocontrol experiments with *Salmonellatyphimurium*on sausages, and reported a 2 $\log_{10}$ reduction of viable cells (28).

4.5. Bacteriophage treatment of Enterobacter

Nosocomial infections are acted by *Enterococcus faecalis* and *Enterococcus faecium*, two gram-positive bacteria that commonly colonize deepen intestinal track. A PlyV12 phage virolysin has been discovered to have lytic effect on those *enterococcus* species as well as on double vancomycin-resistant *E. faecalis* categories (VRE) also three vancomycin-resistant *E. faecium* categories. Vancomycin is an antibiotic that is checked as the final line of barrier against a bacterial pathogen that is already resistant to the other antibiotics (24).

5. CONCLUSION

Based on the few examples demonstrated here, apply of bacteriophages to administer bacterial diseases manifest therapeutic promise. The worldwide broaden of pathogenic bacteria resistant to antibiotics makes it an imperative to exploit alternative strategies to combat this threat.

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REFERENCES

1.Singleton P, Sainsbury D. Key to Book References. Dictionary of Microbiology and Molecular Biology, Third Edition.891-5.
2.Zink R, Loessner MJ. Classification of virulent and temperate bacteriophages of Listeria spp. on the basis of morphology and protein analysis. Applied and environmental microbiology. 1992;58(1):296-302.
3.Kuhn J, Suissa M, Chiswell D, Azriel A, Berman B, Shahar D, et al. A bacteriophage reagent for< i> Salmonella</i>: molecular studies on Felix 01. International journal of food microbiology. 2002;74(3):217-27.
4.Miller A. Eblen BS Oser A, et al.(1998) Application and evaluation of male-specific bacteriophage as a process integrity or faecal contamination indicator in a port slaughterhouse. J Appl Microbiol.85:898-904.
5.Skurnik M, Strauch E. Phage therapy: facts and fiction. International Journal of Medical Microbiology. 2006;296(1):5-14.
6.Carlton RM. Phage therapy: past history and future prospects. ARCHIVUM IMMUNOLOGIAE ET THERAPIAE EXPERIMENTALIS-ENGLISH EDITION-. 1999;47:267-74.
7.Parisien A, Allain B, Zhang J, Mandeville R, Lan C. Novel alternatives to antibiotics: bacteriophages, bacterial cell wall hydrolases, and antimicrobial peptides. Journal of applied microbiology. 2008;104(1):1-13.
8.Ackermann H-W. Frequency of morphological phage descriptions in the year 2000. Archives of virology. 2001;146(5):843-57.
9.Young R, Wang I-N, Roof WD. Phages will out: strategies of host cell lysis. Trends in microbiology. 2000;8(3):120-8.
10.Brüssow H. Phage therapy: the Escherichia coli experience. Microbiology. 2005;151(7):2133-40.
11.São-José C, Parreira R, Vieira G, Santos MA. The N-Terminal Region of the Oenococcus oeniBacteriophage fOg44 Lysin Behaves as a Bona Fide Signal Peptide inEscherichia coli and as a cis-Inhibitory Element, Preventing Lytic Activity on Oenococcal Cells. Journal of bacteriology. 2000;182(20):5823-31.
12.Xu M, Arulandu A, Struck DK, Swanson S, Sacchettini JC, Young R. Disulfide isomerization after membrane release of its SAR domain activates P1 lysozyme. Science. 2005;307(5706):113-7.
13.Fekety R. Antibiotic-associated diarrhea and colitis. Current Opinion in Infectious Diseases. 1995;8(5):391-7.
14.Sturino JM, Klaenhammer TR. Bacteriophage defense systems and strategies for lactic acid bacteria. Advances in applied microbiology. 2004;56:332-78.
15.Hopkins KL, Desai M, Frost JA, Stanley J, Logan JM. Fluorescent amplified fragment length polymorphism genotyping of Campylobacter jejuni and Campylobacter coli strains and its relationship with host specificity, serotyping, and phage typing. Journal of clinical microbiology. 2004;42(1):229-35.
16.Wagner PL, Waldor MK. Bacteriophage control of bacterial virulence. Infection and immunity. 2002;70(8):3985-93.
17.Levin BR, Bull JJ. Population and evolutionary dynamics of phage therapy. Nature Reviews Microbiology. 2004;2(2):166-73.
18.Wommack KE, Colwell RR. Virioplankton: viruses in aquatic ecosystems. Microbiology and molecular biology reviews. 2000;64(1):69-114.
19.Schuch R, Nelson D, Fischetti VA. A bacteriolytic agent that detects and kills Bacillus anthracis. Nature. 2002;418(6900):884-9.
20.Albert MJ, Faruque S, Faruque A, Neogi P, Ansaruzzaman M, Bhuiyan N, et al. Controlled study of Escherichia coli diarrheal infections in Bangladeshi children. Journal of clinical microbiology. 1995;33(4):973-7.
21.Merril CR, Biswas B, Carlton R, Jensen NC, Creed GJ, Zullo S, et al. Long-circulating bacteriophage as antibacterial agents. Proceedings of the National Academy of Sciences. 1996;93(8):3188-92.
22.Raya RR, Varey P, Oot RA, Dyen MR, Callaway TR, Edrington TS, et al. Isolation and characterization of a new T-even bacteriophage, CEV1, and determination of its potential to reduce Escherichia coli O157: H7 levels in sheep. Applied and environmental microbiology. 2006;72(9):6405-10.
23.Mostert JF, Jooste PJ. Quality control in the dairy industry. Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, Third Edition. 2002:655-736.
24.Dorval Courchesne NM, Parisien A, Lan CQ. Production and application of bacteriophage and bacteriophage-encoded lysins. Recent patents on biotechnology. 2009;3(1):37-45.
25.Carlton R, Noordman W, Biswas B, De Meester E, Loessner M. Bacteriophage P100 for control of< i> Listeria monocytogenes</i> in foods: Genome sequence, bioinformatic analyses, oral toxicity study, and application. Regulatory Toxicology and Pharmacology. 2005;43(3):301-12.
26.Wagenaar JA, Van Bergen MA, Mueller MA, Wassenaar TM, Carlton RM. Phage therapy reduces< i> Campylobacter jejuni</i> colonization in broilers. Veterinary microbiology. 2005;109(3):275-83.
27.Goode D, Allen V, Barrow P. Reduction of experimental Salmonella and Campylobacter contamination of chicken skin by application of lytic bacteriophages. Applied and environmental microbiology. 2003;69(8):5032-6.
28.Whichard JM, Namalwar S, William PF. Suppression of Salmonella growth by wild-type and large-plaque variants of bacteriophage Felix O1 in liquid culture and on chicken frankfurters. Journal of Food Protection®. 2003;66(2):220-5.