Reunión de los Estados Partes en la Convención sobre la prohibición del desarrollo, la producción y el almacenamiento de armas bacteriológicas (biológicas) y toxínicas y sobre su destrucción

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Nuevos adelantos científicos y tecnológicos que podrían tener beneficios para la Convención

Documento informativo presentado por la Dependencia de Apoyo para la Aplicación*

Resumen

La Séptima Conferencia de Examen decidió que el programa entre períodos de sesiones para 2012-2015 incluyera un tema permanente del programa sobre el examen de los adelantos en la esfera de la ciencia y la tecnología relacionados con la Convención. La Conferencia también decidió que, con arreglo a este tema, los Estados partes examinarían los nuevos adelantos científicos y tecnológicos que tienen beneficios para la Convención, incluidos los de especial interés para la vigilancia, el diagnóstico y la mitigación de enfermedades. Durante las consultas de los grupos regionales, a principios de junio, los Estados partes solicitaron un documento informativo sobre este tema. El presente documento ofrece una visión general sobre los adelantos de posible importancia. Se basa en el documento informativo sobre los nuevos adelantos científicos y tecnológicos relacionados con la Convención preparado para la Séptima Conferencia de Examen (BWC/CONF.VII/INF.3). El anexo, en inglés solamente, proporciona una descripción más detallada, con referencias a la bibliografía científica.

* Documento presentado con retraso, ya que fue solicitado por los Estados partes después de la fecha prevista.

I. Detección

1. La capacidad de detectar el brote de una enfermedad, localizar a sus agentes y comenzar a aplicar medidas de diagnóstico antes de que aparezcan los síntomas permite reducir el tiempo de organización de la respuesta. Esas acciones pueden disminuir los efectos del brote y sobre todo desalentar la propagación intencional de la enfermedad. Gracias a adelantos científicos y tecnológicos recientes ha aparecido una gama de nuevas posibilidades en este ámbito, a saber: diferentes enfoques; investigaciones sobre el establecimiento de sistemas internos de detección y respuesta tempranas[1]; utilización de los datos de satélite[2]; identificación de los indicadores preclínicos de la enfermedad[3]; empleo de bacterias genéticamente modificadas que brillan en presencia de un agente biológico estresante[4]; sensores visuales para rastrear patógenos y toxinas[5]; y mejoras en la detección ambiental de los agentes[6].

II. Diagnóstico

2. Últimamente se han realizado diversos adelantos en la producción de equipos portátiles y de bajo costo para el diagnóstico de enfermedades[7]. Algunos dispositivos permiten crear capacidades rudimentarias de diagnóstico en partes del mundo que carecen de esos servicios. También ofrecen oportunidades interesantes para trasladar algunas herramientas y técnicas de diagnóstico a los puntos de atención médica, o al menos a un centro regional, en lugar de concentrarlos a nivel nacional[8]. Asimismo se ha avanzado en la creación de capacidades de diagnóstico rápido que permitan dar una respuesta más expedita, eficiente y adecuada a necesidades concretas, incluidos: nuevos enfoques para diferenciar las infecciones bacterianas de las virales[9]; diferenciación genotípica de los patógenos e identificación de los casos de redistribución[10]; identificación de partículas únicas de patógenos o toxinas[11]; diagnóstico en tiempo real de patógenos fúngicos[12]; utilización más amplia de la espectrometría de masas; adelantos en la microscopia; y utilización de la capacidad de secuenciación como instrumento de la salud pública[13]. También se ha avanzado en el desarrollo de ensayos para toxinas más rápidos[14].

III. Prevención y profilaxis

3. Se ha avanzado en la creación de un amplio espectro de vacunas y de nuevos enfoques para su desarrollo[15]. También se elaboran diversos mecanismos novedosos de

[1] http://www.nti.org/gsn/article/researchers-designing-wmd-shield-for-buildings/.
[2] http://www.economist.com/node/13688152.
[3] http://www.biomedcentral.com/1471-2105/9/486.
[4] http://www.nti.org/gsn/article/researchers-develop-lab-on-a-chip-technology-to-test-water-safety/.
[5] http://www.spectroscopyonline.com/spectroscopy/article/articleDetail.jsp?id=376468.
[6] http://daccess-dds-ny.un.org/doc/UNDOC/GEN/G10/639/27/PDF/G1063927.pdf?OpenElement.
[7] http://www.newscientist.com/article/dn14410-ipodsize-microscope-could-become-lifesaving-gadget.html.
[8] http://www.popsci.com/technology/article/2010-02/fingerprint-sized-paper-lab-chip-costs-just-penny.
[9] http://pubs.acs.org/doi/abs/10.1021/ac200596f.
[10] http://wwwnc.cdc.gov/eid/article/17/4/10-1726_article.htm.
[11] http://www.eurekalert.org/pub_releases/2006-11/uog-sbu111506.php.
[12] http://www.ncbi.nlm.nih.gov/pubmed/15893831.
[13] http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0023400.
[14] http://aem.asm.org/content/74/14/4309.full.
[15] http://www.plospathogens.org/article/info%3Adoi%2F10.1371%2Fjournal.ppat.1000921.

prevención de enfermedades. Asimismo, se ha progresado en la búsqueda de métodos para mejorar el sistema inmunitario humano[16]. Por otra parte, los investigadores informan de que han mejorado las técnicas de administración en lo relativo a la profilaxis[17].

IV. Terapéutica

4. El desarrollo de nuevos antibióticos sigue siendo una prioridad en la lucha contra las enfermedades. En los últimos años se han realizado los siguientes logros: creación de nuevas clases de antibióticos; progresos en su caracterización; éxitos en la mejora de su eficacia; identificación de nuevos objetivos; avances en el conocimiento de la forma en que las bacterias vencen a los antibióticos; y mejora de los instrumentos que posibilitan los descubrimientos. Entre los progresos obtenidos en la terapia antiviral se incluyen los siguientes: desarrollo de un medicamento antiviral universal; descubrimiento de nuevos medicamentos; mayor conocimiento sobre el mecanismo de acción de los virus; descubrimiento de un virus antiviral; proteínas viricidas; proteínas que perturban la adhesión del virus a las células del huésped; proteínas que perturban la replicación viral; y reactivos ligantes de alta afinidad que muestran actividad antiviral. La bioprospección ha seguido identificando compuestos terapéuticos potenciales. Asimismo, se ha avanzado en la lucha contra las toxinas, incluidas la manipulación genética de los mecanismos del huésped, nanopartículas para atrapar toxinas y la utilización de anticuerpos para que estas sean expulsadas del organismo.

V. Capacidad de respuesta

5. Se ha avanzado en la determinación de si el brote de una enfermedad se relaciona con patógenos naturales o cultivados[18], en los enfoques estadísticos para el desglose de conjuntos de datos mezclados[19], y en el desarrollo de capacidades microbianas forenses, todo lo cual ayudaría a determinar si ha habido un ataque y su posible autor[20]. Las investigaciones también han demostrado la importancia de la aplicación de medidas de cuarentena eficaces para limitar los efectos de la enfermedad[21]. Los avances de la tecnología de descontaminación, como las espumas antibacterianas, y la utilización de nanopartículas podrían facilitar la limpieza posterior a un ataque[22].

[16] http://www.nature.com/nature/journal/v476/n7361/full/nature10356.html.
[17] http://www.technologyreview.com/news/419880/a-flu-vaccine-without-the-needle/.
[18] http://news.rice.edu/2010/08/16/telltale-signs-of-bioterror/.
[19] http://www.sciencemag.org/content/322/5898/44.1.full.pdf.
[20] http://www.pnas.org/content/early/2011/03/01/1016657108.abstract.
[21] http://wwwnc.cdc.gov/eid/article/16/8/09-1787_article.htm.
[22] http://www.koat.com/print/29135497/detail.html.

Anexo

[ENGLISH ONLY]

Developments with possible beneficial consequences: a more detailed review

I. Detection

1. Being able to detect that a disease event is happening, to track causative agents, and start diagnostic practices prior to symptoms speeds up the timeframe in which a response can be organized. This can reduce the impact of a disease event and possibly reduce the desirability of instigating an outbreak in the first place. Recent advances in science and technology have provided a range of new capabilities in this arena, including: different approaches, such as through native air sampling techniques;[23] research into in-building early warning and response systems;[24] partial prediction systems for normal disease events based on satellite data;[25] the identification of pre-clinical disease indicators, such as the expression of switch-like genes;[26] the use of engineered bacteria that glow when in the presence of a biological stressor, such as a pathogen;[27]the use of membrane immunofiltration analysis with visual sensors for tracking of pathogens and toxins;[28] as well as improvements in environmental detection of agents by nanowire sensors or by immunographic methods.[29]

II. Diagnostics

2. There have been a number of recent advances in the production of cheap and portable equipment for diagnosing diseases.[30] Some of these devices may enable the creation of rudimentary diagnostic capabilities in parts of the world currently lacking such capabilities. The also offer interesting opportunities to move some of the diagnostic tools and techniques currently in use to the point of care - or at least into a regional, rather than national, context.[31] Relevant developments include: the creation of image sensing chips that could lead to the development of highly portable microscopes, similar technology has since been integrated into lens-less microscope prototypes that works with mobile phone technology; a cheap (US$10), pocket size polymerase chain reaction (PCR) machine that runs off two AA batteries which can be used to identify a number of pathogens; as well as the development of paper-based diagnostic ‘chips’ through advances in microfluidics and the use of silica nanoparticles.[32]

[23] http://online.liebertpub.com/bsp
[24] http://www.nti.org/gsn/article/researchers-designing-wmd-shield-for-buildings/
[25] http://www.economist.com/node/13688152
[26] http://www.biomedcentral.com/1471-2105/9/486
[27] http://www.nti.org/gsn/article/researchers-develop-lab-on-a-chip-technology-to-test-water-safety/
[28] http://www.spectroscopyonline.com/spectroscopy/article/articleDetail.jsp?id=376468
[29] http://daccess-dds-ny.un.org/doc/UNDOC/GEN/G10/639/27/PDF/G1063927.pdf?OpenElement
[30] http://www.newscientist.com/article/dn14410-ipodsize-microscope-could-become-lifesaving-
[31] http://www.popsci.com/technology/article/2010-02/fingerprint-sized-paper-lab-chip-costs-just-penny
[32] http://www.popsci.com/technology/article/2010-02/fingerprint-sized-paper-lab-chip-costs-just-penny

3. There have also been advances in rapid diagnostic capabilities, which would also enable a faster, more efficient and tailored response, including through: new approaches to differentiate between bacterial and viral infections;[33]the use of real-time reverse transcription PCR to genotype pathogens and identify reassortment events;[34] the use of Surface Enhanced Ramen Spectroscopy (SERS) to measure the change in frequency of a near-infrared laser as it scatters off viral DNA or RNA allowing the identification of single particles of pathogens or toxins;[35] the real-time diagnosis of fungal pathogens through Selected Ion Flow Tube-Mass Spectrometry (SIFT-MS);[36] as well as the use of sequencing capacity as a public health tool to identify causative agents as well as viral subtypes and reassortment events.[37] There have also been advances in developing faster assays for toxins, such as for the Clostridium botulinum Neurotoxin Type A.[38]

III. Prevention and prophylaxis

4. Certain recent advances have led to the identification of new vaccines. Progress has been made in the creation of broad-spectrum vaccines, such as a pan-influenza vaccine.[39] Genome wide analysis has also shown promising signs for the development of broad spectrum vaccines for bacteria, such as a single vaccine for common E. coli infections. [40] New approaches for vaccination have also been developed. One group reported having identified a standardised approach for genetically manipulating pathogens to make them harmless, whilst still inducing immunity in a mouse model. Another group discovered that they could prevent the replication of a variety of bacterial pathogens, such as those which cause tularaemia, plague, melioidosis, and brucellosis, by exposing a host to cationic liposomes non-coding DNA complexes (CLDC) mixed with pathogen membrane factors.[41]

5. A range of novel approaches to pre-empt disease are also being developed, including making use of advances in the understanding of infections to enable non-pathogenic bacteria to protect against pathogenic viruses, as well as efforts to improve how our immune systems function.[42]

6. Efforts to improve the immune system have included: building self-replicating killer cells from a disabled form of HIV-1 and human T-cells capable of killing target cells, multiplying inside the host and patrolling against relapses and subsequent infections (which has shown dramatic results in three patients to date);[43] building genetically-modified antibodies against specific pathogens by reprogramming human B-cells and assisted by engineered T-cells;[44] advances in our understanding of how the immune system uses antibodies to respond to viral infections after they enter host cells, opening up new opportunities for improving upon the natural process;[45] as well as through the modulation of

[33] http://pubs.acs.org/doi/abs/10.1021/ac200596f
[34] http://wwwnc.cdc.gov/eid/article/17/4/10-1726_article.htm
[35] http://www.eurekalert.org/pub_releases/2006-11/uog-sbu111506.php
[36] http://www.ncbi.nlm.nih.gov/pubmed/15893831
[37] http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0023400
[38] http://aem.asm.org/content/74/14/4309.full
[39] http://www.technologyreview.com/news/421253/a-long-lasting-universal-flu-vaccine/
[40] http://www.ncbi.nlm.nih.gov/pubmed/20439758
[41] http://www.plospathogens.org/article/info%3Adoi%2F10.1371%2Fjournal.ppat.1000921
[42] http://www.nature.com/nature/journal/v476/n7361/full/nature10356.html
[43] http://stm.sciencemag.org/content/3/95/95ra73.abstract
[44] http://hplusmagazine.com/2010/02/02/re-engineering-human-immune-system/
[45] http://www.ncbi.nlm.nih.gov/pubmed/21045130

the gut microbiome to both reduce the chances of infection and reducing the adverse side-effects of antibiotics.[46]

7. There have also been advances in delivering vaccines and prophylaxes, including through trans-dermal patches.[47]

IV. Therapeutics

8. Developing novel antibiotic capabilities remains a priority for the fight against disease. The last few years have seen the creation of novel classes of antibiotics, e.g. Ceftobiprole.[48] It has also seen the initiation of programmes to develop targeted antibiotics that sense and attack specific pathogens.[49] Researchers have also identified a range of new targets for antibiotics, including: manipulating the cell walls of multi-drug resistance bacteria;[50] disrupting flagella and motility;[51] structural elements in RNA polymerases;[52] as well as disrupting quorum sensing systems.[53] Papers published in the last few years have shown how previously uncharacterized antibiotic systems, such as the aminoglycosides, actually work.[54] This might enable the development of improved systems and conformationally similar drugs developed. Research has also identified additional mechanisms by which bacteria overcome antibiotics - both at the genetic level and functionally, such as through the use of nitric oxide-producing enzymes.[55] There have also been advances in new antibiotic discovery technology, for example, through nanotechnology cantilevers to enable high-throughput screening.[56]

9. Perhaps the most promising recent development in anti-viral therapy has been the possibility of developing a broad-spectrum antiviral drug that could kill any cell infected by a virus.[57] Researchers redesigned the enzyme that detects long strands of RNA (which is only produced during viral transcription and replication), which binds to the RNA blocking further production of viral proteins and initiates an extreme self-destruction response. Laboratories trials have shown these drugs to be effective against 15 human pathogens ranging from those that cause the common cold to haemorrhagic fevers. A range of more traditional anti-viral drugs have also been discovered, including: squalamine, a compound that protects sharks from viral infections; RNA interference (RNAi) therapies for Ebola in non-human primates;[58] as well as the identification of novel monoclonal antibody therapies for influenza infections.[59] Research over the last five years has also helped further our understanding of how viruses work, which in turn opens now opportunities for therapies. One group has published, for example, how Ebola infects cells. A second team used a more sophisticated understanding of Ebola to create a siRNA protocol designed not to cure Ebola but to hold its replication in check until the hosts immune system could begin to respond

[46] http://www.ncbi.nlm.nih.gov/pubmed/18197175
[47] http://www.technologyreview.com/news/419880/a-flu-vaccine-without-the-needle/
[48] http://newswire.rockefeller.edu/2008/07/02/new-antibiotic-beats-superbugs-at-their-own-game/
[49] http://www.nature.com/news/2010/100414/full/464970a.html
[50] http://www.cbc.ca/news/health/story/2010/10/08/bacteria-cell-wall-trick.html
[51] http://www.ncbi.nlm.nih.gov/pubmed/20676082
[52] http://www.cell.com/abstract/S0092-8674(08)01190-2
[53] http://www.newscientist.com/article/dn16563-new-antibiotics-would-silence-bugs-not-kill-them.html
[54] http://www.cell.com/abstract/S0092-8674(08)01195-1
[55] http://www.sciencemag.org/content/321/5887/365.abstract
[56] http://www.newscientist.com/article/dn14912-nanolevers-could-speed-up-hunt-for-superbug-drugs.html
[57] http://www.plosone.org/article/info:doi%2F10.1371%2Fjournal.pone.0022572
[58] http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(10)60357-1/fulltext
[59] http://www.cidrap.umn.edu/cidrap/content/influenza/panflu/news/feb2309monoclonal-br.html

effectively, which in turn allowed a monkey to recover from the disease. In 2008, researchers discovered virophages - viruses which spread at the expense of other viruses. Such a discovery offers possibilities for the design of anti-viral virus therapies.[60]

10. There have also been relevant advances in developing therapies to deal with toxins, including: the identification of genetic sequences in hosts required for intoxication by ricin and Pseudomonas exotoxin (offering treatment opportunities by blocking the functionality of these genes);[61] nanocarriers designed to allow toxins to be flushed from the system;[62] nanoparticles designed to trap toxins and carry them to the liver for destruction;[63] compounds designed to prevent the uptake of toxins into certain cell types, such as botulinum toxin into nerve cells;[64] as well as small binding agents designed to latch on to toxins enabling them to be identified by antibodies, also allowing it to be flushed from the system.[65]

11. Several research groups have also been developing more unusual therapeutic approaches. Developments in the understanding of human metabolic network topology in disease have led to the development of multi-target drugs designed to disrupt disease-related molecular networks.[6667] Equally, advances in sequencing capabilities have enabled the use of comparative genome wide analysis to identify novel targets for drugs. One research group has developed non-biological nanofactories designed to prevent bacterial replication offering an entirely new approach for therapeutics via nanomaterials. Another group built a nanoparticle that disrupts bacterial cells walls and shows promise in treating bacteria that have become multi-drug resistant. There is also an ongoing research project to develop adjutants that help break up bacterial infections into single cells, making them more sensitive to existing antibiotics.[68]

V. Response capacity

12. Over the past five years there have been advances that improve capabilities to investigate if an attack has taken place and who might be responsible. Researchers are currently working on a way to identify cultured pathogens (as opposed to those that have evolved in nature).[69] This would help determine that a disease event has a deliberate or accidental origin, rather than being caused naturally. New statistical methods have also been developed to identify individual genotypes from samples comprised of mixed genetic data or from aggregate SNP data enabling better tracing of specific agents during investigations.[70] Perhaps most importantly, recent years have also seen the release of some of the microbial forensic procedures and practices used to investigate the use of B. anthracis filled envelopes as a weapon in the United States.[71]

13. Data published since 2006 also has implications for restricting the spread of a disease event. A paper published in August 2010, for example, demonstrated that quarantine methods are effective in preventing secondary outbreaks. Although enforced

[60] http://www.nature.com/nature/journal/vaop/ncurrent/full/nature10380.html
[61] http://www.asiaone.com/News/AsiaOne+News/Singapore/Story/A1Story20110724-290762.html
[62] http://www.ncbi.nlm.nih.gov/pubmed/18654405
[63] http://pubs.acs.org/doi/abs/10.1021/ja102148f
[64] http://www.ncbi.nlm.nih.gov/pubmed/21832053
[65] http://news.tufts.edu/releases/release.php?id=156
[66] http://www.pnas.org/content/105/29/9880
[67] http://www.ncbi.nlm.nih.gov/pubmed/18985027
[68] http://www.ncbi.nlm.nih.gov/pubmed/18985027
[69] http://news.rice.edu/2010/08/16/telltale-signs-of-bioterror/
[70] http://www.sciencemag.org/content/322/5898/44.1.full.pdf
[71] http://www.pnas.org/content/early/2011/03/01/1016657108.abstract

quarantine is a traditional disease control measure, relevant legislation in many countries has not been updated recently and may be inconsistent with subsequent developments in rights and freedoms.[72]

14. There are also advances which will help clean up after a disease event. One group, for example, reported in 2011 having developed a decontamination foam capable of killing pathogens such as that which causes anthrax, using nothing more than chemicals found in common household materials. [73]

[72] http://wwwnc.cdc.gov/eid/article/16/8/09-1787_article.htm
[73] http://www.koat.com/print/29135497/detail.html