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Eurobiofilms 2022: A translational perspective of biofilm-related persistent infections

After fruitful meetings in Rome, Copenhagen, Ghent, Brno, Amsterdam and Glasgow, the ESCMID (European Society of Clinical Microbiology and Infectious Diseases) Study Group for Biofilms (ESGB) organized the 7th edition of the EuroBiofilms meeting in Mallorca (Spain), from August the 31st to September the 3rd, 2022. The multidisciplinary program covered many subjects and encompassed both basic and clinical biofilm related topics.

This special issue (https://www.sciencedirect.com/journal/biofilm/special-issue/1059MP74K6Z) gathers a collection of 22 papers on clinical concerns and research trends addressed during the congress.

EuroBiofilms 2022 (EBF 2022) brought together more than 250 biofilm researchers, from 27 countries and 4 continents. The congress was preceded by two educational workshops at the Medical School of the University of the Balearic Islands (UIB) Son Espases University Hospital (HUSE) and Illes Balears Health Research Institute (IdISBa), on "Antibiotic treatment strategies, PK/PD parameters and resistance development in biofilm models" taught by Estrella Rojo-Molinero and María Fernández-Billón (from the Local Organizer Committee [LOC], HUSE, Palma), and "In Vivo Biofilm models: establishment, endpoints and treatment testing" taught by Claus Moser and Christian Lerche (Copenhagen University Hospital-Rigshospitalet, Denmark). The bulk of the congress took place at the Hotel Melià Palma Marina, where 60 oral sessions (11 from invited speakers and 49 selected from submitted abstracts) and 5 keynote lectures were given, and 158 posters were presented. Several biofilm-related topics were addressed from a translational perspective, sharing the most cutting-edge advances in research and trying to link basic knowledge with direct application to clinical practice and thus, progress in the prevention and treatment of chronic infections.

In the afternoon of the first day (August 31st), after the welcome by the ESCMID Study Group for Biofilms (ESGB) and LOC, presidents, Gordon Ramage (University of Glasgow, UK) and Antonio Oliver (HUSE, Palma, Spain), respectively, as well as local authorities (Nacho García Pineda, General Director of Pharmacy), the opening lecture was given by Dr. José María Miró (Hospital Clinic of Barcelona, Spain); the topic addressed in this presentation was the clinical management of biofilm-related infective endocarditis.

The next day (September 1st), the meeting continued with a morning lecture by Susanne Häussler (Copenhagen University Hospital-Rigshospitalet, Denmark and Hannover Medical School, Germany) about bacterial adaptation to biofilm growth. Chronic osteoarticular and wound infections were discussed later in the parallel session 1 chaired by Oscar Murillo (Hospital Universitari de Bellvitge, Barcelona, Spain) and Kendra Rumbaugh (Texas Tech University Health Sciences Center, US). In this session, results about the use of hyperbaric oxygen therapy (HBOT) in improving the bactericidal activity of ciprofloxacin against *Pseudomonas aeruginosa* in wound biofilm *in vivo* were presented. This communication has led to a manuscript by Laulund et al. [1], where it is also found that HBOT, in addition to ciprofloxacin, modulates the host response to a less inflammatory phenotype. Related with the topic of the session, four interesting studies presented as posters at the EBF 2022 are included in this special issue: Lamret et al. [2] have developed an innovative *in vitro Staphylococcus aureus* biofilm model of prosthesis infection, Baz et al. [3] have found a promising application of direct cold atmospheric plasma therapy in combatting wound and skin-related biofilm infections, Shirgill et al. [4] have explored the antimicrobial activity of silver-based dissolution ions, from silver-based biomaterials, as a potential treatment for wound-associated bacterial biofilms and, finally, Morales-Laverde et al. [5] have investigated the genetic components associated with the capacity of *S. aureus* to colonize the surface of medical implants.

Parallel session 3, "Heterogeneity and metabolic adaptations at the special biofilm microenvironment" was chaired by Thomas Bjarnsholt (Costerton Biofilm Center, Copenhagen, Denmark) and Susanne Häussler, and this special issue includes several papers related to this session, including that of Cornejo et al. [6], which focuses on the effect of sex steroid hormones on the ecology of *in vitro* oral biofilms. Similarly, the research presented by Davis et al. [7] shows that plaque acid-tolerance was increased in individuals with active caries compared to caries-free individuals. In addition to specific findings, the study proves the possible role of the probiotic strain *Limosilactobacillus reuteri* in caries prevention by inhibiting the development of an acid-tolerant biofilm microbiota.

One of the most notable sessions of the congress was on alternative therapeutic strategies to fight biofilms (parallel session 4) and a high number of publications in this special issue are related to the topic of this session. Elisa Borghi (University of Milano, Italy, educational Officer of ESGB) and Joana Azeredo (University of Minho, Portugal, treasurer of ESGB) chaired this session. The latter gave a lecture on "Strategies to improve phage efficacy against infectious biofilms", which has led to the manuscript by Akturk et al. [8] about combining phages and antibiotics to enhance the efficacy against an *in vitro* dual species (*S. aureus* and *P. aeruginosa*) wound biofilm. The results of this work suggest that antibiotics (gentamicin) can be effective adjuvants for phage therapy when treating chronic wound infections. However, the order and frequency of the applied antimicrobials (phages or antibiotics) are important for an optimal treatment outcome [8].

In the same session, Olivier Lesouhaitier presented the oral communication "The human Atrial Natriuretic Peptide as a powerful weapon against *P. aeruginosa* biofilm". The work has been expanded to

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the study by Louis et al. [9], where it was found that the natriuretic peptide receptor osteocrin agonist disperses established biofilms of *P. aeruginosa*, thus suggesting its use as a potential antibiofilm agent [9]. Additionally, this special issue includes three works, presented as posters at EBF 2022, related to alternative therapeutic strategies to combat biofilms. Hoogenkamp et al. [10] have investigated the application of hydrogen peroxide in the *in vitro* control of biofilm growth and removal of *Vermamoeba vermiformis* from multi-kingdom dental unit water biofilms. Youf et al. [11] evaluated the ability of ruthenium (II) complexes to photo-inactivate bacteria under complex experimental conditions mimicking the microenvironment in chronically infected airways. Maybin et al. [12] proved that a short cold atmospheric-pressure plasma (CAP) sub-lethal pre-treatment can be an effective strategy for enhancing the susceptibility of *P. aeruginosa* biofilms to antimicrobials, providing important mechanistic insights into CAP-antimicrobial synergy.

The congress continued (September 2nd) with a lecture titled "The pathogenicity of biofilms: the paradigm of chronic wounds" by Kendra Rumbaugh (Texas Tech University, US). Afterwards, the parallel session 5 on "Novel technologies to study biofilms", chaired by Eduard Torrents (University of Barcelona, Spain) and Elena Jordana-Lluch (LOC, HUSE, Palma, Spain), inspired two publications, presented as poster at EBF 2022; the work by Crisp et al. [13] describes a novel application of Infra-Red (FTIR) spectroscopy to evaluate the chemical composition of bacterial biofilms without disrupting the biofilm architecture, whereas De Bleeckere et al. [14] presents a high throughput assay to assess the antimicrobial susceptibility in *P. aeruginosa* biofilms in the context of cystic fibrosis.

In parallel session 7 ("Optimizing antimicrobial efficacy to treat biofilm-related infection") chaired by Oana Ciofu (Costerton Biofilm Center, Copenhagen, Denmark) and Antonio Oliver, a work by Fernández-Billón et al., "Therapeutic strategies based on antagonistic resistance mechanisms between novel β-lactam and carbapenem antibiotics to combat XDR *P. aeruginosa* biofilms" was presented. The same authors provided the special issue with a comprehensive review on the mechanisms of antibiotic resistance in *P. aeruginosa* biofilms [15], particularly focused on mutational resistance. This paper is also linked with parallel session 2 chaired by Frank Schreiber (Federal Institute for Materials Research and Testing, Berlin, Germany) and Mariló Macià (LOC, HUSE, Palma, Spain) and titled "Mechanisms of antibiotic resistance in biofilms".

Parallel session 8, chaired by Gordon Ramage and José Luis López-Ribot (The University of Texas at San Antonio, US), was focused on "Fungal biofilms in 2022 -how far we come?". López-Ribot gave the lecture "Antifungal agents for the treatment of biofilms: past, present and future" which is summarised in the paper by Ajetunmobi et al. [16] providing a historical view, as well as a current and future perspective on antifungal agents and therapy of *Candida* biofilms. Other studies related to fungal biofilms are also included in this special issue. Delaney et al., who presented the oral communication "Understanding biofilm heterogeneity and adaptation in *Candida*", propose an integrated transcriptomic and metabolomic method to investigate *Candida albicans* biofilm phenotype [17]. The original article by Žiemytė et al. [18], by using real-time monitoring of biofilm growth, identified andrographolide, a natural compound isolated from the plant *Andrographis paniculata*, as a potent antifungal compound able to eradicate *Candida* biofilms. Cross-kingdom biofilms are also discussed, with the work by Díaz-Navarro et al. [19], which assessed co-cultures of *C. albicans* and *Escherichia coli* in a large collection of vaginal samples.

EBF 2022 addressed on its last day the clinical relevance of microbial biofilms in the clinical setting, with parallel session 9 about "Cystic fibrosis and chronic respiratory infections", chaired by Jaime Esteban (Fundación Jiménez Díaz, Madrid, Spain) and Antonio Oliver (LOC and HUSE, Palma, Spain). Esteban presented the lecture "*Mycobacterium* biofilms and chronic infections", and in the related paper "*Mycobacterium* biofilms" by Muñoz-Egea et al. [20], an exhaustive review on the clinical relevance of mycobacterial biofilm, its diagnosis, susceptibility testing, and treatment is presented.

Simultaneously, at parallel session 10, chaired by Niamh Harrington (University of Warwick, UK) and Estrella Rojo-Molinero (LOC, HUSE, Palma, Spain), the issue "Cooperation, competition or quite the opposite: The complex interactions in biofilm communities" was addressed. On this topic, Johnston et al. [21] presented a poster at the EBF 2022 and wrote a paper about the efficacy of the *Gardnerella*-specific endolysin CCB7.1 against *G. vaginalis* in polymicrobial biofilms altering the overall community dynamic and composition.

The EBF meeting ended with a Final Plenary Session with the objective of reviewing the recommendations, drawing conclusions, and projecting future perspectives. Two of the leading global experts in biofilm research, Niels Høiby (Copenhagen University Hospital-Rigshospitalet, Denmark), and Tom Coenye (Ghent University, Belgium), both past chairmen of ESGB, gave the lectures. "Time to update the ESCMID guidelines for the diagnosis and treatment of biofilm infections?" was the title of that given by Niels Høiby with the aim of re-examining the ESCMID guideline for the diagnosis and treatment of biofilm infections published in 2014 [22]. An opinion paper on this aspect is now available in this special issue of Biofilm [23]. Finally, Tom Coenye talked about "The future of research in biofilms: Towards which horizon should we walk?".

Although there are still many unknowns in the field of chronic biofilm-related infections, their diagnosis, and management, both the congress and this special issue demonstrate that considerable advances have been made in basic and applied knowledge about biofilms.

The next EBF meeting will take place from 26 to 29 June 2024 in Copenhagen, Denmark. More information can be found at https://eurobiofilms2024.dk/.

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María D. Macià*
Department of Microbiology, Hospital Universitario Son Espases, Health Research Institute of the Balearic Islands (IdISBa), 07120, Palma de Mallorca, Spain
Centro de Investigación Biomédica en Red en Enfermedades Infecciosas, Instituto de Salud Carlos III (CIBERINFEC), 28029, Madrid, Spain
Study Group for Biofilms (ESGB), European Society for Clinical Microbiology and Infectious Diseases, Basel, Switzerland

Elisa Borghi
Dept. of Health Sciences. Università Degli Studi di Milano, Via Di Rudinì 8-Blocco C, 8° Piano, 20142, Milan, Italy
Study Group for Biofilms (ESGB), European Society for Clinical Microbiology and Infectious Diseases, Basel, Switzerland
E-mail address: elisa.borghi@unimi.it.

Antonio Oliver
Department of Microbiology, Hospital Universitario Son Espases, Health Research Institute of the Balearic Islands (IdISBa), 07120, Palma de Mallorca, Spain
Centro de Investigación Biomédica en Red en Enfermedades Infecciosas, Instituto de Salud Carlos III (CIBERINFEC), 28029, Madrid, Spain
Study Group for Biofilms (ESGB), European Society for Clinical Microbiology and Infectious Diseases, Basel, Switzerland
E-mail address: antonio.oliver@ssib.es.

* Corresponding author. Department of Microbiology, Hospital Universitario Son Espases, Crta. Valldemossa 79, 07120, Palma de Mallorca, Spain.
E-mail address: mariad.macia@ssib.es (M.D. Macià).