Participants not only enjoyed the lively atmosphere at the congress but also the city of Moscow with its rich cultural and historical heritage, famous museums, and magnificent architecture. The friendly attitude of the hosts, the perfect organization of the congress and the very nice and convenient congress venue at Sechenov University were highly appreciated.

Details of the event can be found by at www.ecardiohealth2018.org.

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Conclusions and Take Home Messages are discussed by Hugo Saner

eCardiology and eHealth are rapidly evolving and will become an important component of today's medical care. This report summarizes the most important conclusions and take-home messages from this past congress.

Digital skills for the cardiologist of tomorrow

A group of promising European Society of Cardiology (ESC) young cardiologists discussed how the challenges of the digital future could be converted into opportunities.

An outstanding statement was '*artificial intelligence* will not replace physicians, but physicians who use artificial intelligence will replace those who don't'. Therefore, 'don't be afraid, but be prepared!'. Another important quotation was 'The most important thing in science is not so much to obtain new facts as to discover new ways of thinking about them'. In regard to the *e-learning challenge*, Leonardo da Vinci was cited saying 'simplicity is seen as the ultimate sophistication'.

The speakers made the promising impression, that many of the ESC young cardiologist community are ready to tackle future challenges and are not afraid to do this based on visionary statements from the past.

The role of computational models in improving healthcare pathways

Personalized biomedical computational cardiac models have the ability to integrate multiple domains of information and to provide new knowledge over and above conventional measures. As an example, three-dimensional reconstruction methods of stented coronary models from optical coherence tomography images can be used for fluid dynamics simulations in coronary stents, and the reconstruction method has successfully been used to create patient-specific stented models, which will allow to perform the large population studies in the future. *Coronary computed tomography (CCT)-based and automated non-invasive assessment of the fractional flow reserve (FFR)* are a promising tool to guide indications for intervention by using automatic coronary graph reconstruction and automated virtual FFR_{CT} estimates. *Multiscale modelling and simulation of in silico human trials* using individualized computer simulations for drug safety and efficiency are very advanced and have a high accuracy to predict *in vivo* risk of arrhythmias.

E-imaging, E-intervention, and emergency care

Coronary computed tomography is a valuable non-invasive method for assessing coronary vessels and plaque parameters in patients with coronary disease. The presence of low-density areas and irregular contour in plaques observed by computed tomography are two important signs of vulnerable plaques. There is a strong need to remotely review and to discuss patient data including cardiovascular imaging. A novel *municipal networked Cath lab sharing system* may turn out to facilitate data exchange between Cath labs and to economize Cath lab activities.

Multimodality imaging including fractional flow reserve assessment using three-dimensional quantitative coronary angiography-based software is in an advanced stage of development and will become a standard part of the modern Cath lab. *Artificial intelligence* will become a major role for digital imaging processing and interpretation. Robot-assisted tele-stenting is promising but many unsolved questions remain.

Smartphone as a lab and beyond

The *smartphone* will become the major element connecting human affairs with the digital world and the cyber network of devices, to become the ultimate Health Hub.

Vampire-like suction devices will let patients draw blood at home, perform tests at home, and send the results to the doctor.

Genomes will be at your fingertips through direct-to-consumer testing.

Nanotechnology-based tests for cancer and other diseases are in development by Google.

Results from *robotic medical nano-devices* powered by nano-flexible batteries and controlled by wireless technology are on the horizon.

Transdermal laser scanning will help to detect infections such as Malaria in seconds. And *pocket-size imaging devices* are used for screening programmes in schools, industry, and community activities, for first cardiac evaluations in ambulances and emergency settings, for cardiology counselling in- or outside healthcare facilities and hospitals and as teaching tools.

Therefore, we will see a transition from the traditional hospital- or office-based visits to technology-based encounters.

Telemedical solutions for specific conditions

Transmitting of results from *home measurements of blood pressure* and single-lead ECG to a central unit by smartphone are promising technologies particularly in large countries and regions with limited access to medical care in remote areas such as Australia and Siberia. Around 10% of the measurements are interpreted as critical (>160/100 mm Hg). False-positive results and unnecessary hospitalizations continue to remain a problem. Research in *smartphone-based home care* seems to be particularly advanced in Australia.

An extremely exiting topic is the use of *ballistocardiography*, to diagnose heart disease. Micro-electro-mechanical systems using accelerometers and gyroscopes have been first tested in space during a Salyut 4 expedition in 1980 and have been further developed during parabolic flights by the European Space Agency (ESA) to measure acceleration and rotation of the heart.

Kino-cardiography is computing kinetic energy and power generated by the heart and blood motion and has the potential to become a valuable tool in clinical practice to detect changes in stroke volume or deconditioning in healthy subjects and to detect changing heart conditions in heart failure (HF) patients.

Remote patient management of HF patients using telemedicine was another emerging topic of the congress. It became evident that current proof of benefits is evident only for heart failure patients in functional class NYHA II/III with a recent heart failure hospitalization due to fluid overload decompensation. New sensor technologies for data

acquisition and new systems of continuous data transfer have a great potential to further improve telemedical systems for HF patients and more patients may benefit from this technology in the future. *Remote control of data from invasive pressure and haemodynamic monitoring* may become another clinical useful application but will be restricted to specific situations in highly selected HF patients. The real issue for any innovative solution may be scalability.

The use of *telerehabilitation* to improve cardiac rehabilitation uptake is around the corner. A *virtual rehabilitation coach* at home is one promising approach. Remote delivery of cardiac rehabilitation supplemented by telecommunication shows encouraging results. Using *human–computer interaction* approaches and subtle interaction design when working on eHealth/mHealth in a multidisciplinary team improves user acceptance and may lead to increased motivation and adherence.

Tackling arrhythmias in the digital health era

Remote telemonitoring systems for surveillance of patients with electronic devices such as pacemakers or ICDs are well advanced, but the application is still limited for various reasons. Data reliability (false alarms due to artefacts and analytic errors), clinical data flow, doctor's workload, and clinical acceptance issues are major obstacles to a general use in daily practice. Better ECG classification systems and implementation by intelligent decision support systems to speed up the diagnostic process are already in clinical use. Better pre-processing of the raw ECG signal, heartbeat segmentation, feature extraction, and classification using classic machine learning and neural network analysis will contribute to great progress in data analysis and hopefully to a wider applicability of such systems.

Early detection of atrial fibrillation is a topic of intense research around the world. A large variety of ECG monitoring systems using short- or long-term registration sequences are under research and development. The application of continuous data transmission from a skin patch to the smartphone and from there to a cloud-based solution with a fully (inter-) connected 'Hub and Spoke' ECG data acquisition and monitoring platform is a promising new technology to overcome local or regional deficits in service provision.

Tackling hypertension in the era of digital health

Web-based telemedicine software linked to various medical devices such as blood pressure monitors, ECG, spirometers, pulse oximeters, cardiorespiratory polysomnography devices, and laboratory analysis is already standard for data acquisition, analysis, processing, and review by health professionals. However, poorly controlled hypertension for various reasons remains a big challenge. Some of these factors may be amenable to modification. The addition of *wearable chemical-electrophysiological hybrid biosensing systems* for real-time health and fitness monitoring to gather additional supplementary information are in an advanced stage of development and may become useful to improve the reliability of remote monitoring data. But the most exciting news was that *blood pressure measurements using the smartphone camera* seem to be around the corner. The application is based on the use of photo-plethysmography technology which is validated by the application of machine learning techniques using data from simultaneous individual ECG and traditional blood pressure recordings.

Cardiovascular prevention and lifestyle tracking

Although an unhealthy lifestyle contributes to a great extent to disease development and progress, 85–90% of healthcare expenditures are allocated to medical care, whereas health expenditures for preventive interventions account for only around 5% in most developed countries. New technologies using *eHealth platforms for patient's education and information*, *wearable sensors* for tracking of blood pressure, glucose monitoring, stress levels, and physical activity may help to improve prevention efforts.

A very promising application of the smartphone is to use *smartphone photos to calculate carbohydrate and calorie content of a food plate* in actual daily life and may turn out as a valuable tool to help people reduce calorie intake if necessary, to decrease obesity prevalence and to improve glycaemic control in diabetic patients. mHealth may also contribute to patient empowerment.

Remote prevention counselling via text messaging or E-mails shows its first promising results for weight loss and improvement of metabolic disorders in patients with obesity. A national *home-monitoring* trial in Australia has shown the most promising first results: over 1 year, primary healthcare services fell by 24%, unscheduled admissions to hospital also fell by 24%, length of stay in a hospital fell by a mean of 34 days, mortality was reduced by 32%, and significant improvements of mental health measures were observed [full report available from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) website https://www.csiro.au].

The use of *ambient contactless motion sensors* combined with a ballistocardiograph bed sensor for monitoring of heart rate and respiration shows promise not only for the detection of emergency-situations but also to gather preventive information. The potential of such an ambient sensor system for early detection of HF decompensation at the patient's home has been demonstrated.

Final remarks

Regulations, safety, and security of digital health application have been extensively discussed. Questions and concerns around these topics have been expressed in many sessions. There is still a wide gap between technical progress and clinical application. Many barriers for implementation exist.

However, it became evident at this congress that although barriers are recognized, much energy and enthusiasm to overcome these barriers is spent around the world.

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