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EUROPEAN HOSPITAL

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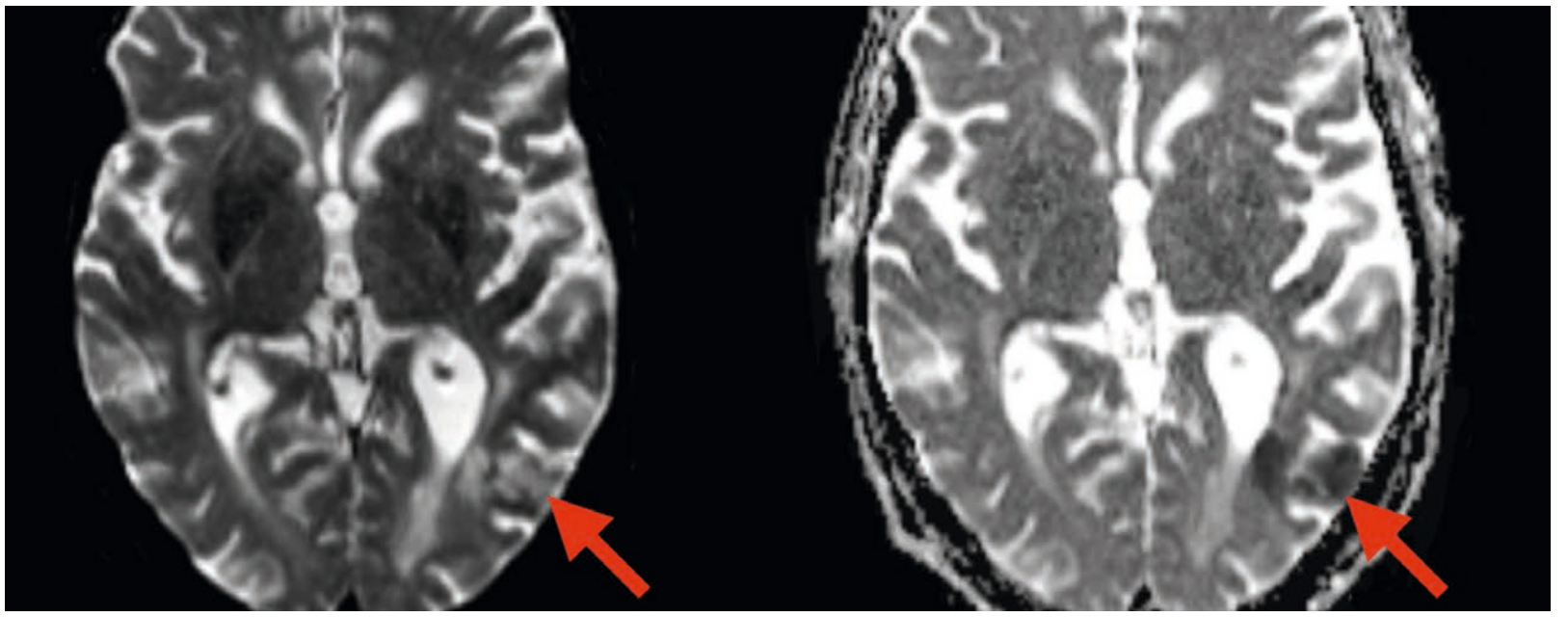
Cancer patients at risk

Blood test detects risk of neurotoxicity from CAR T-cell therapy

Chimeric antigen receptor (CAR) T-cell therapy is an immunotherapy treatment that re-engineers a patient's own T-cells to help them attack malignant tumour cells. It has been very effective in the treatment of blood cancers, including certain types of leukaemia and lymphoma. However, two serious side effects are common as a result of the treatment: cytokine release syndrome (CRS) and immune effector cell-associated neurotoxicity syndrome (ICANS).



Evidence of a stroke (red arrows) is seen on this MRI scan of a brain of a patient who developed neurotoxic side effects after CAR T-cell therapy.
© Dr Omar H. Butt of Washington University at St. Louis

Researchers in Germany and in the United States have separately determined that high levels of serum neurofilament light chain (NfL), a protein in the blood indicative of neuroaxonal injury, are associated with ICANS complications. A simple blood test identifying NfL levels can help identify cancer patients who are at risk of developing ICANS following CAR T-cell therapy. ICANS represents a broad spectrum of neurologic symptoms ranging from mild confusion, tremor, headaches, difficulty reading, difficulty concentrating, lethargy, and memory problems to severe brain swelling, seizures, coma, and even death. Between 40% to 60% of patients receiving CAR T-cell therapy develop ICANS.

Two independent studies, one conducted at the Washington University at St. Louis (WUSTL) and the other by a multi-institutional German team led by researchers at Ludwig Maximilian University (LMU) of Munich, have identified that higher NfL levels in cancer patients' pre-CAR T-cell treatment correlate with the severity of subsequent ICANS.

German multi-institutional study

Principal investigator Prof Louisa von Baumgarten, MD, of LMU's University Hospital, and co-researchers hypothesized that neuroaxonal integrity might have an important role in determining the severity of ICANS. Their hypothesis was based on numerous studies demonstrating that NfL serum levels correlate well with cerebrospinal fluid levels, mirror the extent of neuroaxonal injury, and predict outcomes for severe neurologic conditions, including multiple sclerosis, neurodegenerative disorders, traumatic brain injury, and ischemic stroke.

Ninety-six patients being treated at CAR T-cell therapy centres at LMU and University Hospital Heidelberg had their serum NfL levels measured five days before treatment, the day of treatment, and on the day that maximum ICANS symptoms were exhibited. NfL pre-levels were significantly higher in patients who developed moderate to severe ICANS after CAR T-cell transfusion than in patients reporting no or mild ICANS. Both post-treatment and pre-treatment NfL levels correlated with the severity of the subsequent neurotoxicity.

Predicting severe neurotoxicity

Writing in Blood Advances, the researchers said, 'These findings suggest that measuring the level of NfL – alone or in combination with known risk factors such as tumour burden, CAR T-cell expansion, systemic inflammation, and immune system activation – might be useful to predict severe neurotoxicity after CAR T-cell transfusion […]. Our data imply an increased risk for more severe ICANS as a result of neuroaxonal injury if NfL – pre-treatment is greater than 75 pg/ml.' They are currently validating the predictive value of NfL levels in a prospective setting, and correlating findings with EEG, fMRI, and comprehensive neuropsychologic testing.

USA study

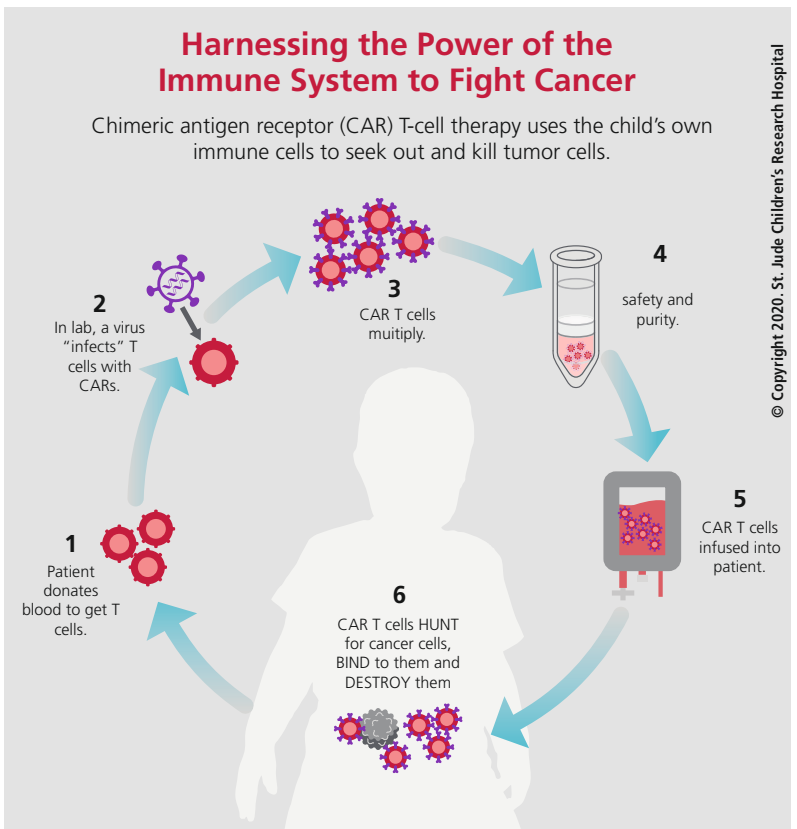
Armin Ghobadi, MD, and Beau M. Ances, MD, PhD, both of WUSTL, led a similar study, published in JAMA Oncology. They measured plasma NfL levels of 30 patients receiving CAR T therapy at WUSTL and Case Western Reserve University in Cleveland at seven timepoints, starting at baseline pre-CAR T infusion to 30 days after. They analysed NfL levels in patients who developed each severity grade of ICANS and those who did not, as well as age, sex, tumour burden, history of neurologic disease, and history of neurotoxic therapies.

'Patients who developed any grade ICANS had significant elevations in baseline NfL level,' they write. 'Baseline NfL level correlated with ICANS grade. No association was observed with demographic, oncologic, neurologic, or exposure to neurotoxic risk factors, such as CRS. The risk of developing ICANS is associated with pre-existing neuroaxonal injury that was quantifiable with plasma NfL level in a subset of patients.'

Ongoing prospective trial

WUSTL lead author Omar H. Butt, MD, PhD, tells European Hospital that the team is scaling up to wide scale testing in the near future. 'We are also trying to determine where in the brain this injury originates, how this injury interacts with the immune system to develop symptoms, and how long the injury lasts after symptoms along with its lingering consequences. All these questions are under active investigation with an ongoing prospective trial integrating advanced neuroimaging with blood and spinal fluid biomarkers and neurophysiological testing in patients undergoing cellular therapy.' ■

Report: Cynthia E. Keen



CONTENTS

Sustainability

The challenge of greening medical technologies

Under the impulse of the European Commission, the in vitro diagnostic (IVD) industry is developing emerging technologies to implement sustainable practices in medical laboratories.

The in vitro diagnostics industry has a significant environmental impact due to the generation of biomedical and chemical waste, the use of toxic chemicals and the consumption of energy to produce and use diagnostic equipment. According to a study published in the journal Environmental Science & Technology, the medical diagnostics industry generates 5.4 million tonnes of waste each year, the majority of which is made up of plastics. In addition, chemicals used in diagnostic tests such as organic solvents, acids and bases can be harmful to the environment. 'They can lead to soil and water contamination as well as greenhouse gas emissions,' said Elisabetta Bigoni of the Department of Civil and Environmental Engineering at Politecnico di Milano, Italy, in her study on the environmental sustainability of in vitro diagnostics: critical hotspots and improvement perspectives.

EU Green Deal & EFLM task force

As sustainability has been a growing priority of the European Union (EU) in the last decade, 'the medical technology sector, particularly the IVD sector, must comply with European legislation in this field like all other sectors,' said Oliver Bisazza, CEO of the European trade association Medtech Europe representing the medical technology and diagnostics industries.

In December 2019, the European Commission adopted the European Green Deal. Its goal: to accelerate Europe's efforts to become the first climate-neutral continent by 2050, in line with the Paris Agreement on climate change. The green and sustainable laboratories initiative roadmap published by the European Commission in June 2021 proposed several concrete actions such as adopting sustainable medical technologies and materials and more efficient waste management. The roadmap also calls for the creation of an expert group to monitor and gauge the actions taken.

Last year, the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) launched its „green labs" task force to improve their sustainability across Europe and beyond. In vitro diagnostics companies are deploying several emerging technologies, mainly in the field of biochips and recycling processes.

Sustainable biochip technologies

The microarray technology allows the detection of multiple biological targets simultaneously on a single chip. This makes a faster and more efficient sample analysis possible. The latest technical advances aim to reduce the environmental impact of the automatons used. For example, US-based company Agilent Technologies has designed its SurePrint G3 durable biochip technology using synthetic DNA for long-term use with an extended life span of the print head and consumables. Material consumption is reduced by 80% compared to previous platforms while saving an average of 40% on material costs. In addition, Agilent offers a recycling programme for used microarray plates. This reduces waste even further.

Swiss company Roche has developed the NimbleGen SeqCap Ez platform for its reusable DNA hybridization probes. In terms of environmental performance, the use of this platform reduces hybridization probe consumption by up to 50% compared to traditional sequence capture methods. It also reduces the waste associated with the use of these probes.

US-based biotech company Illumina, a specialist in sequencing, genotyping and gene expression, has relied on its Beadchip platform, which uses fluorescent beads to detect thousands of biological markers in a single sample with an accuracy of over 99%. The Beadchip technology saves up to 75% on reagent and material consumption compared to traditional genotyping methods. The latter uses microarrays that contain millions of green beads covered with DNA probes.

Recyclable materials and eco-design of in-vitro diagnostic medical devices

The sustainable development of the IVD industry requires diagnostic tests to have a low environmental impact. The use of recyclable materials for IVD test packaging and components continues to grow. Roche Diagnostics announced in March 2021 that it would use 100% recycled plastic for its product packaging. In the same year, the Greiner Bio-One Group also announced that it would manufacture its products using biobased and recyclable materials. According to the recent Grand View research study, the global medical device packaging market size was valued at €27.61 billion in 2020 and is expected to expand at a compound annual growth rate (CAGR) of 6.4% from 2020 to 2028 to €45.41 billion in 2028.

Eco-design technologies are not to be outdone. There are currently three main trends. First, the use of biobased and biodegradable materials, such as corn starch, polylactic acid, cellulose and chitosan, aims to reduce the environmental impact of plastic waste. Secondly, microfabrication processes such as deep immersion lithography and 4D printing are used to reduce energy consumption in the production of IVD devices. Lastly, the development of portable and rechargeable diagnostic systems reduces the amount of waste generated by disposable consumables.

New partnership model in the in vitro diagnostic industry

Smart technologies are helping sustainable development through a new 'partnership model to efficiently integrate and adopt energy technologies and innovations,' said EFLM's President Tomris Ozben. New technologies such as artificial intelligence (AI), quantum computing and supercomputing could help deliver safer and more sustainable chemicals and materials by design. The IVD industry can mobilize several partnership models around public-private partnerships, collaborations between companies in the same sector and partnerships with non-governmental organizations.

These partnerships foster sustainable development while enabling the widest possible access to in vitro diagnostics. For example, Bio-Rad Laboratories and Sartorius Biotech have developed locally prduced Covid-19 test kits using less plastic. Abbott and the Bill & Melinda Gates Foundation have deployed the Pima portable diagnostic system for malaria in several countries in East Africa, Southeast Asia and Latin America. ■

Report: Bernard Banga

Other useful smart and green lab techniques

Spectroscopy uses light to identify molecules in a sample. It can be used for non-destructive analysis of biological samples, and therefore for multi-sample analysis.

Digital PCR can detect and quantify DNA with extreme accuracy in infectious diseases: 'a sensitivity of 97.5% and a specificity of 100% for the detection of B. burgdorferi, the pathogen that causes Lyme disease,' said Mark Eshoo, founder and CTO of San Diego, California-based BlueArc Biosciences and MWE Lifesciences. Digital PCR displays a a sensitivity of 91.3% and a specificity of 97.7% for the detection of Streptococcus pneumonia, the bacteria responsible for pneumonia.

Microfluidics allows the manipulation of liquid biological samples at the micrometre scale. This technology offers dramatic developments for biological analysis processes and five significant advantages: fewer samples and reagents (volume reduced to the nanolitre), real-time analysis, 'Automation, which reduces associated waste, miniaturization, which reduces transportation-related greenhouse gas emissions, and recycling of materials, which reduces costs and associated waste,' said Muhammad Saqib Sohail, researcher in electronic and computer engineering at the Hong Kong University of Science and Technology, Hong Kong.

In turn, digitizing diagnostic data reduces the amount of paper and plastic needed to store test results. This reduces waste and energy consumption: a 30-50% reduction in paper consumption and a reduction of up to 30% in energy consumption associated with medical data storage and management.

Pre-eclampsia

Detecting high-risk pregnancy with heart attack test

About five percent of all women develop so-called pre-eclampsia during pregnancy, which in severe cases can become life-threatening for mother and child and require an emergency caesarean section. Until now, the risk has been determined rather unspecifically on the basis of factors such as diabetes, obesity or the mother's age. Using commercially available troponin tests, high-risk patients could be identified much earlier and more accurately than before, an approach from Freiburg, Germany, shows.

Prof. Dr. Dirk Westermann, Medical Director of the Department of Cardiology and Angiology at the Medical Center – University of Freiburg presented this completely new approach at the Congress of the American College of Cardiology (ACC) in New Orleans, USA.

Predicting severe courses

Troponin tests have long been used in acute diagnostics for suspected heart attacks. 'We were able to show that the troponin level in the blood is very closely associated with the risk of later pre-eclampsia. In particular, severe courses of the disease can presumably be predicted very well. This could make early and targeted prevention possible in the future,' says Westermann.

The numerous risk factors for pre-eclampsia include being very overweight, diabetes, previous multiple pregnancies and a very young or old age of the mother. If several of these factors come together, the pregnant women are closely monitored and receive prophylactic medication with aspirin.

But: 'By far not all women with risk factors actually develop pre-eclampsia. We were able to show that women with a low troponin level did not develop pre-eclampsia despite risk factors.

Prof. Dirk Westermann
© University of Freiburg

'Thus, about 40 percent of the women would not have needed closer care,' says Westermann. For their study, the Freiburg physicians examined 3,080 blood samples from four international studies of a total of 2,293 pregnant women.

'We can already treat women with pre-eclampsia very well today. So far, however, the causes of the disease are unknown, which makes diagnosis much more difficult. A reliable test that can indicate the development of pre-eclampsia at an early stage would be a great help,' says Prof. Dr. Ingolf Juhasz-Böss, Medical Director of the Department of Gynaecology at the Freiburg University Medical Center. In the next step, the German researchers want to check their results in a prospective study and combine the data from the troponin test with other risk factors. In this way, the safety of pregnant women and their unborn children could be further increased. ■

Source: Medical Center – University of Freiburg

Flow cytometry

Detecting and measuring nanoplastics in the blood stream

Plastics are a part of everyday life, and an increasingly concerning factor of global environmental pollution. They also have infiltrated our bodies as microparticles (MPs) and nanoparticles (NPs), found even in placentas supporting foetal life. And they are in our blood. Now, researchers in Spain have developed a new method to detect and measure nanoparticles in human peripheral blood that is faster and more accurate than some current techniques being used.

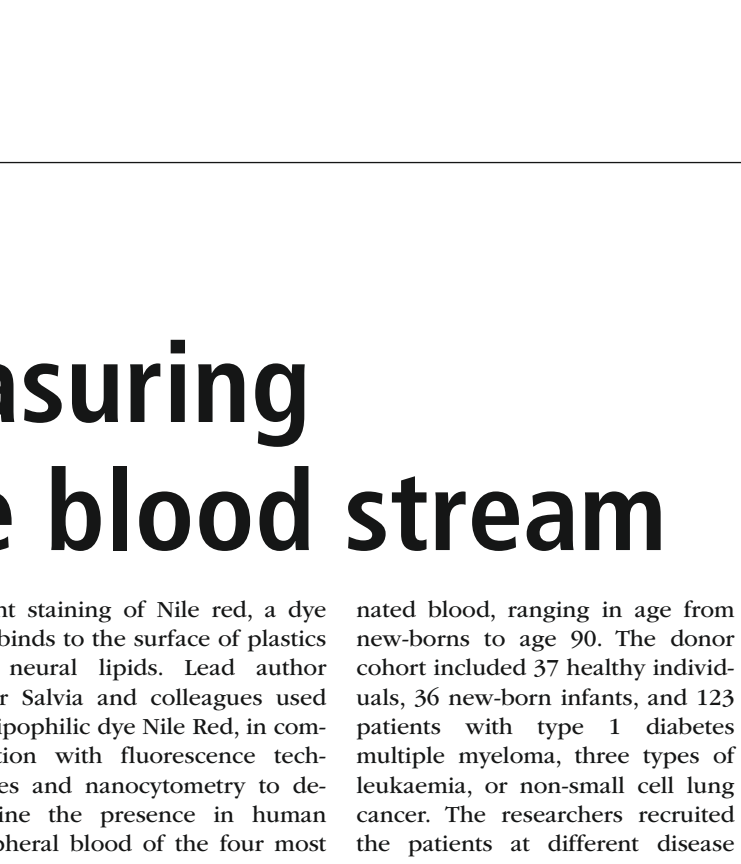
Plastic MPs and NPs are ingested through oral intake of food and liquids, air inhalation, and exposure to the skin, such as bathing and using personal care products containing nanoparticles. Ranging in size up to 5 mm for MPs and from 1 nm to 1000 nm for NPs, they most commonly enter the body through food, drinking water, and use of plastic food contact materials.

Microplastics and nanoplastics are now known to induce inflammation, oxidative stress, immune response, and cell death through apoptosis and necrosis. When nanoplastics reach the blood stream, they circulate throughout the body. Because almost all blood from the intestinal tract transfers through the liver, this is a particularly vulnerable organ. Accumulations of plastic particles in the liver can penetrate the epithelial barrier. A study conducted by Chinese researchers at Shandong University's Institute of Toxicology in Jinan, determined that that polystyrene nanoparticles increased blood-brain barrier (BBB) permeability and accumulated in the brains of mice. This accumulation triggered activation of microglia, the cells of the brain that regulate brain development, maintenance of neuronal networks, and injury repair. The researchers reported that their study revealed that polystyrene nanoparticles induced microglia activation and neuron damage in the mouse brain.

Barcelona study reveals prevalence of plastics in the blood

Although more than a decade has been spent in intensive global research, the extent of harm plastic particles can cause to the human body is still unknown. Tens of thousands of variables are involved in terms of assessing exposure, hazards, and effects on human anatomy. Accurate and reproducible detection and measurement techniques are essential for all research.

A Universitat Autònoma de Barcelona research team has developed a simple, fast, robust, and reproducible method to detect nanoplastics in human peripheral blood using a flow cytometry method. Flow cytometry is a laser-based technique used to detect and analyze the chemical and physical characteristics of cells or particles. The researchers' method, described in MethodX, is based on the fluorescent staining of Nile red, a dye that binds to the surface of plastics and neural lipids. Lead author Roser Salvia and colleagues used the lipophilic dye Nile Red, in combination with fluorescence techniques and nanocytometry to determine the presence in human peripheral blood of the four most common plastics produced in the world. 196 people living in the Metropolitan Area of Barcelona donated blood, ranging in age from new-borns to age 90. The donor cohort included 37 healthy individuals, 36 new-born infants, and 123 patients with type 1 diabetes multiple myeloma, three types of leukaemia, or non-small cell lung cancer. The researchers recruited the patients at different disease timepoints, which ranged from diagnosis and treatment to post-hematopoietic transplantation.



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Their study to assess the capabilities and accuracy of their flow cytometry method was designed to prevent surface and airborne sample contamination by plastic particles and the environment. All measurements were performed in triplicate.

All participants had plastic in blood

Based on the blood analysis, all participants had plastic particles in their blood. The researchers determined accumulation of plastics in participants aged 40 to 90 years slightly decreased as based on older age. 'This suggests that the accumulation [of NPs] in other tissues, such as adipose tissue, cannot be ruled out,' they write. More studies will be needed to enlighten how plastics are accumulated with age, as an age-related phenomenon of redistribution and exposure to plastic pollution.'

The researchers also hypothesized that the air pollution in and around Barcelona was a potential source of plastic particle airborne inhalation. They conducted a laboratory study with mice, with results suggesting their hypothesis is accurate. The team recommends that studies be conducted to assess the accumulation of plastics in people living in rural areas and locales with different population densities. ■

Report: Cynthia E. Keen

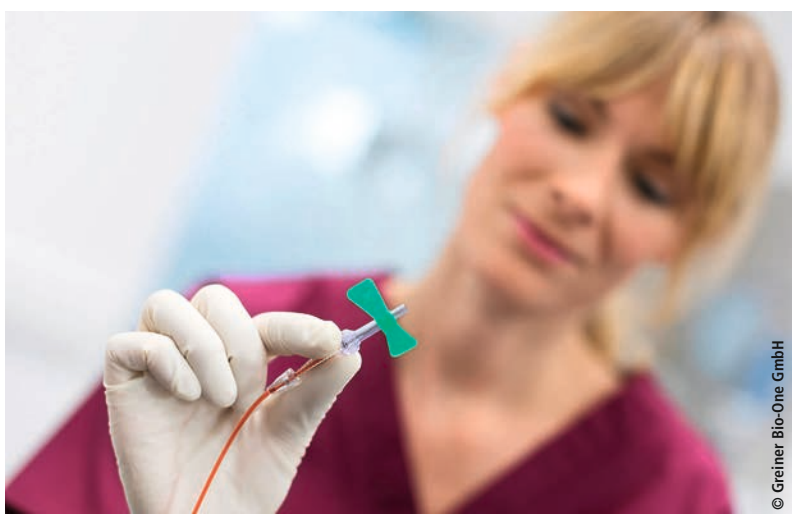
Sponsored • Safe blood collection products and value-based care

Protecting patients and healthcare staff

In the last decade, regional and global health organizations have pushed for making safety a central pillar of procurement, with a directive that cost should not be a barrier. The crucial question is: How easy is that to implement? How can a confident decision be reached that protects patients and healthcare workers without straining costs?

A Royal College of Nursing project reported that 100,000 needlestick accidents occur in the UK every year, and Bevan Brittan, a legal firm representing the NHS, estimates the cost of needlestick injuries to each UK NHS trust to be around £500,000 each year in legal costs. And in the US, the initial treatment of a needlestick injury (NSI) can cost between US$ 800-6000 each, with initial costs of medication for the Hepatitis C virus starting at around US$ 25,000, and fines from OSHA beginning at US$ 13,260. It should be noted that this is before associated costs are taken into consideration; staff absence interrupts the efficiency of already heavily burdened departments, and reputational damage and morale pose a considerable challenge to a sector that is struggling with staff retention.

The takeaway is that indirect costs exceed the direct costs. The EU and OSHA are rigorous in their safety directives with regards to NSI, and arriving at a decision in selecting a safety device that balances costs without sacrificing safety need not be a complicated process.


© Greiner Bio-One GmbH

Which criteria should be used to evaluate a safety device?

An established culture of safety feeds into the selection process. But with a vast inventory of products available, how can this process be simplified? The decision should be based on the three pillars frontline healthcare worker input, ease of use and protecting patient safety and comfort.

How does a reliable supply chain support safety?

The culture of safety is in place, a short list of prospective manufacturers has been identified, fulfilling the code of conduct and sustainability criteria and the costs are clear. Should the cheapest option then be chosen? This is where a reliable supply chain can really add value in blood collection. Logistics have been transformed and optimized due to the pandemic, but still face a host of challenges; the costs of raw materials continue to increase and global events impact the availability and delivery of goods. So how does one manufacturer's offering compare to a competitor's?

Go with the safety flow

The small details of blood collection kit matter in the lab, just as much as they do on the ward. It is why every detail of products and services from Greiner are designed with that safety approach in mind. From the moment a blood sample is drawn, to the moment it becomes data. ■

Read the full article by scanning the code.

State of the art and latest advances in technology

Robotic assistance in the operating room

Surgical robots are becoming widespread in operating theatres, delivering accuracy and safety. An overview of the main systems, principal operators, the market and European initiatives in this field.

MUSA, the world's first clinically available CE marked microsurgery robot © Microsure BV

Modern surgery has come a long way in the past decades, thanks to improved techniques, tools and medical equipment. However, traditional surgery still has some limitations, including accuracy as well as fatigue and hand tremors in surgeons, which can impact the quality of procedures. For example, with spinal surgery, accuracy of movement must be better than 2 mm to avoid spinal cord injury. The threshold for errors is very low too, with a rate lower than 3% being necessary to avoid serious postoperative complications. In brain surgery, these margins become even smaller, with movement accuracy > 1 mm and error rates > 2%. Ophthalmic surgery takes this to the extreme, with an accuracy limit better than 0.5 mm to avoid corneal damage, and error rates less than 1%.

1.5 million robot-assisted procedures each year

These limitations have led to the emergence of robot-assisted surgery, which has dramatically increased the accuracy of surgical procedures while reducing hospitalisation times and postoperative complications. Surgical robots have been designed for use in a wide variety of surgical procedures across multiple fields, including cardiology, gynaecology, and urology.

The latter has seen an especially pronounced surge in robotic use; while in 2008, only 1.5% of urology surgery was performed with robot assistance, this has skyrocketed to over 43% today, according to various hospital sources. In total, some 1.5 million surgical procedures are performed worldwide using surgical robots. The advantages of this are manifold, including access to difficult areas through the use of slender, flexible robotic arms and on-board cameras, stable navigation of surgical instruments, significant reductions in operating times and hospital stays, as well as a reduction in postoperative complications (bleeding, infections, etc.).

According to the colloquium paper "The state of the art of robotic surgery", presented in October 2022 in Lyon, France, at the French Association of Biomedical Engineers congress, 71 technology options for automation and assistance with surgical gestures are currently available from 63 companies around the world.

The procedures that have benefited most from surgical robotics include prostate removal and renal ureter repair, gastrectomy, cholecystectomy and colectomy, plus heart valve surgery and coronary bypass surgery, along with total hip and knee replacements. This is a burgeoning market expected to be worth $14.9 billion by 2028.

Three robotic systems

The top five surgical robot manufacturers by market share in 2020 were Intuitive Surgical, Stryker, Medtronic, Zimmer Biomet, and Smith & Nephew. Intuitive Surgical supplies four robots for urology, ENT, abdominal and gynaecology surgery – the Da Vinci and Ion platforms. These have a market share of more than 69% between them. Stryker has the Malo platform, with a motorised arm holding cutting instruments (oscillating saw, acetabular burr) linked to an infrared stereoscopic system for partial knee replacement surgery. Medtronic has developed two systems: a semi-automatic navigation assistant named the Mazor X Stealth Station, for rectifying spinal deformity, and the Hugo RAS multi-port remote guidance system.

Zimmer Biomet markets a semi-automatic navigation assistant for partial and total knee replacement, its Rosa Knee robot. Finally, Smith & Nephew has the Navio FPS platform, a manual navigation assistant using a handpiece combined with an optical navigation system designed for partial and total knee arthroplasty. Faced with the emergence of numerous surgical robots, the biomedical and equipment department at Geneva University Hospitals in Switzerland, together with the Swiss Foundation for Innovation and Training (SFITS), have just published a guide listing and classifying all automation and assistance technology options for surgical gestures. This collaborative effort is the result of a year-long survey of robots on the market. 'The process of choosing and introducing these high-tech systems into the complex environment of the hospital must be subject to a structured and complete methodological approach,' explains Hervé Jacquemoud.

His team distinguishes between guidance assistants, laparoscopy devices and telesurgery systems. 'Depending on whether the guidance assistants have a motorised arm, an instrument holder and whether they perform the procedure autonomously, we classify these into visualization assistants and manual, semi-automatic or automatic guidance assistants,' the expert continues. Within the category of automatons, robots are sub-classified as motorised or non-motorised augmented instruments, or motorised endoscope holders. Finally, telesurgery systems are said to be single-port when only one incision is required, and multi-port for several.

Future generations of surgical robotics supported by the EU

The number of knee replacement procedures in OECD countries is expected to increase from 2.4 million procedures today to 5.7 million by 2030. 'Currently, 95% of procedures are performed with no robotic assistance and with a very high patient dissatisfaction rate of more than 20%,' observes Sophie Cahen, co-founder and CEO of Ganymed Robotics. Her med-tech company, based in Paris, France, has been selected by the EU for inclusion in a project which hopes to develop a compact robot to make joint replacement surgery more precise and less invasive. The initial focus is on total knee replacement, though Ganymed is looking to expand this to other joints including the shoulder, ankle and hip. This advanced robotics for optimised orthopaedic surgery project has been awarded a €3.5 million grant. Since its inception in 2018, the French startup has rapidly validated its proprietary algorithm based on pre- and intra-operative data collected via an observational study on 100 patients. 'We aim to offer the first compact, ergonomic, intuitive and cost-effective robotic device,' says Cahen. This next generation of robot introduces computer vision-driven intelligence and perception into the operating theatre, allowing contactless localisation of the patient's anatomy and opening the way to data-driven operating theatres.

Microsure, based in Eindhoven, the Netherlands, is a spin-off from Eindhoven University of Technology (TU/e), and has developed the world's first clinically available CE-marked microsurgery robot. The Meet MUSA project, funded by the EU to the tune of more than €2.6 million, will tackle the obstacles to successful product roll-out, including scaling up and optimising manufacture. Mechanics, electronics engineers, software developers and control engineers at Microsure have designed a system where surgeons look through 3D glasses at a large screen connected to a digital microscope positioned above the patient. The movements made by the surgeon using joysticks are detected and transformed into highly accurate movement of the small, lightweight robot attached to a platform fitted with arms able to hold and manipulate microsurgical instruments.

In a 2020 study, surgeons reported using MUSA to treat breast cancer lymphoedema, a chronic condition that commonly occurs as a side effect of cancer treatment and is characterised by a swelling of body tissue as a result of a build-up of fluids. To perform the surgery, the robot sutures tiny lymph vessels measuring just 0.3 to 0.8 mm in diameter to nearby veins in the affected area. 'Given this large unmet need in microsurgery, we are convinced that the time is right to launch MUSA on the market,' said Sjaak Deckers, CEO of Microsure. The company will introduce MUSA across Europe by 2029, confident that that it will achieve major social and economic impact. ■

Report: Bernard Banga

Five generations of surgical robots

1980 – neurosurgery. The first generation of surgical robots was developed for neurosurgery. The robot was used to position a probe in the brain with great precision. This first generation of robots were manufactured by AESOP Medical (US) and ZEUS Robotics (Canada). The AESOP robot was controlled by a remote surgeon, while the ZEUS robot had a more advanced interface, allowing the surgeon to control the robot's movement.

1990 – remote control. The second generation of surgical robots saw the introduction of robotic laparoscopy surgery. The robot was able to control the surgical instruments remotely, allowing the surgeons greater precision and ease of use. The manufacturers of this generation of robots were Intuitive Surgical, Computer Motion, and SRI International, all from the US. The Intuitive Surgical robots were the most advanced, offering surgeons greater dexterity, accuracy, and stability.

2000 – more indications. The third generation of surgical robots was characterised by the extension of robotic surgery to include cardiac and orthopaedic surgery. Robots from this generation were more compact, easier to use and more precise than previously. The manufacturers here were Intuitive Surgical, MAKO Surgical, plus Mazor Robotics from Israel. Intuitive Surgical robots dominated the market with their advanced technology, high precision, and ease of use.

2010 – the limits of precision pushed back. The fourth generation of surgical robots saw the introduction of precision robotic surgery, with robots capable of even more precise movements and control of surgical instruments. The robots in this generation were also smaller and more portable than before. Manufacturers included Intuitive Surgical, TransEnterix and Verb Surgical, all from the US.

2020 – artificial intelligence enters the operating theatre. Surgical robots use artificial intelligence (AI) to improve the precision, speed, safety, and reliability of surgical operations. For instance, the French company Robocath has developed R One, a robotic system for assisting cardiac surgery which uses AI to learn a surgeon's exact movements in order to optimise the pathways taken by surgical instruments.

Affordable and widely accessible

How robotics technology is being applied in support of patient wellbeing

Keeping technology simple and affordable is key in helping patients to fully benefit from robotic systems, according to a leading expert in the field.

While expensive and complex systems have been developed, Professor Heike Vallery believes the full potential of robotics in patient care will only be realised when they become more affordable and widely accessible. She also underlines the importance of the sector being confident enough to 'share failures' to advance knowledge of what works and what does not work in terms of robotics for patients.

Robotic technology is advancing healthcare over a range of areas in the operating theatre with RAMIS (robotically-assisted minimally invasive surgery), in terms of transport and moving products within hospitals and pharmacies, and patient rehabilitation and even preventive healthcare. Soft robotic technology and improved sensors are driving this.

Complex technology

Vallery, who was among the keynote speakers in the 40th ICRA (International Conference on Robotics and Automation) in London, is an expert in robotics to improve patient mobility, particularly those who have motor-impaired conditions or suffered a stroke. With advances in robot technology in healthcare explored during the five-day event alongside innovation in robotics in manufacturing and domestic settings, her presentation "Subtractive design of robotics to empower individuals with motor impairments" highlighted the need for simpler solutions.

Speaking to European Hospital ahead of the event, she said: 'When applying robotics with the aim to empower motor-impaired individuals, often highly complex technology results, which hinders implementation in daily life.' She underlined the importance of achieving functionality that really makes a difference for the individual. Recent results from experiments with robotic body-weight support systems surprisingly challenged assumptions on what humans need or prefer in order to walk or balance better.

Her team discovered that simpler solutions were just as effective and even favoured by patients over complex equipment. 'This demonstrates the importance of engaging with users at an early stage and of distilling key requirements,' said Vallery. 'Often, devices are proposed that are overly complex and expensive, accessible to only a very few people, but many of the key functionalities that help users can be done with simpler systems.' The devices her team is working on include cable robot systems with harness, pulleys, and motors to support human movement, or prosthetic legs for elderly users who have trouble standing up.

She strongly advocates the importance of research teams sharing setbacks as well as successes in their different approaches. 'We tested a prosthetic leg that users were not putting weight on and it actually made it harder for them to stand up or sit down,' said Vallery. 'We analysed how it went wrong and observed that we had disregarded the ankle, the foot was too rigid. We were augmenting the knee but found it does not help if you do not support the ankle.' She pointed out that publishing on areas where things did not always go according to plan and sharing lessons learned creates a healthier research environment and ultimately advances the field.

Knee exoskeleton that provides both flexion and extension assistance during walking, to improve weight-bearing ability. © ICRA

Small margins

The emphasis with patient robotics is now seeing researchers and companies focusing on simpler devices for people's homes. 'We are moving from devices costing several hundred thousand Euros and only affordable to large rehabilitation centres to very simple technology,' she explained.

The sector is also acknowledging that margins of improvement after a stroke or other neurological condition can often be small. 'But sometimes people can get over a certain threshold that allows them to functionally use certain limbs again and that is the reason why we make these types of devices.' However, she also noted how the administrative burden from new medical device regulations is impacting smaller players in the market. Her career at Delft has centred on robot-assisted rehabilitation and prosthetic legs in collaboration with clinicians and industry partners, and with a move to RWTH Aachen, Germany, she will continue the focus on simpler robotic technology.

Keynote session

The keynote session at ICRA on healthcare highlighted how robot technologies can take on different aspects of patient care against a backdrop of aging populations, increasing healthcare costs, and a shortage of healthcare professionals. The development of specialized sensors, magnetic positioning, machine learning algorithms, highly-flexible snake-arms robots, and intelligent decision-making systems that enable robots to safely carry out complex tasks within a healthcare setting are accelerating the advances.

Energy burst

Wearable robotics are being adapted from patient rehabilitation into "prehabilitation" to help people stay active for longer. Simona Crea, Assistant Professor at Scuola Superiore Sant'Anna (SSSA) in Pisa, Italy, explained that they are also being applied in industrial settings, specifically with preventive healthcare in mind.

An important area of development is to make walking and locomotion activities, such as moving from sitting to standing, easier. A focus of her work is on developing robotically-supported exoskeletons for patients who spend higher energy when walking, such as those with diabetes, who may undergo lower-limb amputation when the disease progresses too much. 'Such patients typically have high metabolic consumption when they walk, so walking is very difficult,' said Crea. 'They tend to walk much slower.' Making walking easier for these patients may result in a more active lifestyle and therefore a reduced risk to develop complications due to sedentary life. The powered exoskeleton gives them 'an additional burst of energy.'

Physical training

The technology also has value in the rehabilitation of stroke patients, but, in parallel to developing systems that are more comfortable to use, she stressed the importance of making devices lighter yet without sacrificing mechanical power. 'That is a key design challenge,' added Crea, who co-leads the wearable robotics laboratory of the SSSA's BioRobotics Institute.

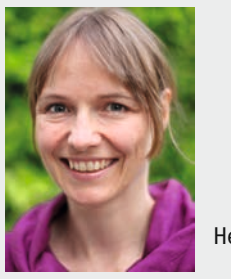
'At the same time, we need a device that understands, in real time, what the user's intention is in moving.' She uses the phrase 'prehabilitation' to explain how wearable robotics can help 'enhance and enrich' the walking experience for older people and support their physical training. 'For example, this could be training at higher velocities, volumes, or workloads without significantly increasing the metabolic consumption of the user.'

Worker wellbeing

She advocates a role for 'wearable robots for sustainable aging,' which she outlined in her presentation to the ICRA congress. Wearable robots are being designed for industrial applications, but even here they also have a healthcare application. As Crea explained: 'They can be used as tools that prevent development of musculoskeletal injuries or disorders at work. There is momentum in this field of prevention.

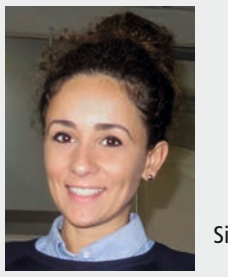
'The technology is for the wellbeing of the worker, to preserve and sustain the musculoskeletal system by reducing the biomechanical load on specific joints.' ■

Report: Mark Nicholls



Heike Vallery

Heike Vallery graduated in 2004 with honors from RWTH Aachen University with a Dipl.-Ing. degree in Mechanical Engineering. Since then, she has been working on robot-assisted rehabilitation and prosthetic legs. In 2009, she earned her Dr.-Ing. from the Technische Universität München and then continued her academic career at ETH Zürich, Khalifa University and TU Delft. Today, she is a full professor at RWTH Aachen and TU Delft, and also holds an honorary professorship at Erasmus MC in Rotterdam. Her current research focuses on developing minimalistic and unconventional concepts to support human gait and balance.



Simona Crea

Simona Crea is a tenure-track Assistant Professor at Scuola Superiore Sant'Anna (SSSA) and co-leads the SSSA wearable robotics laboratory. Her background is in Biomedical Engineering and her research experience is in the field of wearable robotics for rehabilitation, assistance, and augmentation of human motor functions.

More quality time for patients

Transport robots help care staff

Surveys and studies regularly arrive at the same conclusion: care staff, particularly in hospitals, want more time to spend with the patients. Persistent staff shortages, however, continue to increase the staff's workload and thus render this wish well-nigh impossible. But there might be help around the corner: the Fraunhofer Institute for Manufacturing Engineering and Automation IPA developed a flexible transport robot to support care staff in hospitals.

Being a hospital nurse entails considerable footwork: moving between patient rooms, departments, the lab and different storage rooms, nurses can chalk up several kilometers during a single shift. The time spent in the hallways means less time for bedside patient care. Engineer Dr Birgit Graf and her team at Fraunhofer IPA addressed this issue in their MobDi project by developing a transport robot that can lift any cart with sufficient ground clearance and take it to the desired location – be it laundry or meal carts, garbage or beverage carts. 'Length and width of the robot chassis can be adjusted according to the size and wheel base of the cart to be transported,' Graf explains. 'The transport robot can move in any direction and is thus suitable even for confined spaces. A 360° safety system with sensors makes sure that the robot does not present a danger to people.' Moreover, the system can be preprogrammed to execute certain tasks at certain times or be used spontaneously as required.

Care staff can direct the robot via app. © Fraunhofer IPA

Robot, fetch!

A possible scenario could be as follows: at the beginning of a shift the robot places the required number of carts – let's say with bed linen or care utensils – to predefined locations. When that cart's stock runs out during the shift the nurses can order replacements on their mobile phone. The robot then brings the restocked cart to the room where it is needed. At the end of the shift the robot takes all carts back to the storage room. Thus the nurses can stay with the patients while new material is being fetched; due to its mobility, the robot can support several team members.

While the robot takes over the transport, restocking the carts still needs to be done manually by human colleagues. But Dr Graf's team had an idea how to solve this problem: modular baskets at an automated changing station. Graf explains that 'each modular basket contains the items necessary for a certain task, for example taking blood samples or changing wound dressing. When all items in the basket are used up, the robot automatically moves to the changing station and replaces the baskets – without human intervention.'

Sensors for stock management are particularly helpful. 'Each item taken from the stock is scanned. When the available stock has reached a certain level and needs to be replenished, a message is sent to the staff,' says Graf. 'Since the system is linked to the facility's material management system, an order can be placed immediately.' Each cart can be equipped with this technology but it is particularly simple to implement with patient care carts featuring a screen that provides access to the documentation system.

Sensors scan each item taken from the shelves to facilitate stock management. © Fraunhofer IPA

The prototype of the transport robot has been extensively tested in the Fraunhofer labs. 'Now would be a good point in time for an industry partner to come on board,' Graf points out, since a market-ready robot could be developed rather quickly. The economic benefits have already been verified in a sample calculation. 'In a 100-bed facility, a robot that takes on the entire transport of fresh and soiled laundry has paid off within three years. If it takes on more tasks, that period is even shorter.' ■

Report: Sonja Buske

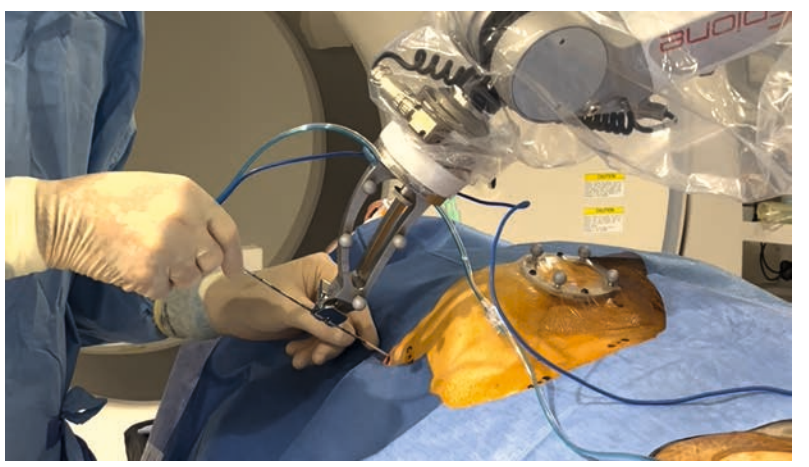
Improving accuracy

Robots push the door of interventional radiology

Long confined to surgery, robots are making their first steps in interventional radiology. Those devices could help improve accuracy in tumour targeting during needle insertion and help less experienced radiologists perform ablations, a leading French interventional radiologist showed at the Spectrum conference in Miami.

Robots have gone a long way ever since they were introduced to the field of neurosurgery in 1985. Many devices are available today, and some have the potential to boost interventional procedures, according to Thierry De Baère, professor of medicine at Paris Saclay University and Head of Interventional Radiology at Gustave Roussy Cancer Centre in France.

For over a year, his team has worked with the Epione robot system from French manufacturer Quantum Surgical, which has shown promising early clinical results in more than 100 patients for ablation procedures and other needle guided procedure at Gustave Roussy. The team has used the robot for various types of procedures including cryoablation, RFA and MWA in the liver and kidney, as defined by the device's CE mark. But the French group also used the robot off-label in bone reconstruction and lung thermal ablation. Their experience has been very positive, De Baère explained. 'The robot is giving you the needle trajectory and placing the needle on track,' he said. 'The robotic system of needle insertion is safe, highly feasible and requires only a few needle adjustments. It provides efficient thermal ablation.' Steps for robotic needle insertion include image acquisition, needle trajectory planning, robot placement, needle insertion and image verification. 'You align the centre of the ablation to the centre of the tumour, then you're all set and ready to send the robot,' he said. 'You send the arm to the location established in the treatment planning. And all you have to do is to push the needle in a single step from the skin to the target, which is something that we're not used to.' After the insertion, radiologists can see where the needles are and correct the position if needed. An interesting possibility with the system is how it can expedite needle insertion in procedures where multiple needles are required, De Baère explained. 'Tumour ablation in the kidney can be complex and time consuming if we have to stick many needles,' he said. 'With the robot, insertion of one additional needle was below one minute in most of our patients, and below two minutes for the rest. Once we decide our trajectory, we can go faster with the device.'



Prof. Thierry Jacque De Baère at work with Quantum Surgical's Epione robot.

There are several areas where the system could help advance interventional radiology, he went on. 'The robot increases the degree of freedom for needle insertion in any plane. This could offer more stable guidance and accuracy at the time of placing the needle tip at the centre of the target,' he said. A second benefit concerns dose reduction. 'As interventional radiologists we get a lot of radiation when we are working and dose matters to both patients and physicians,' he said. 'With a robot, it's obvious that you can decrease radiation to physicians because they are no longer inside the room.' One more thing De Baère hopes to achieve with the robot is more homogeneity in axial and oblique plan needle insertion. 'In oblique plan puncture, you don't see the whole plan during the entire needle placement,' he said. 'With the robot, there should be no variation, as it gives you angle free trajectory, offering a new way to approach the tumour.'

Last but not least, there is a short learning curve for the system and beginners can start working very fast with the equipment. 'Everybody can do the same. For a beginner it's great,' said De Baère, who compared the performance of three experts with ten years' experience with that of a novice without prior experience in sticking needles. 'In just a few days, the beginner was doing as good as we have done for the past 20 years,' he said. Another significant benefit with the robot is its respiratory monitoring function. 'It's better to work under apnea, because the target is moving with the breathing, so you need to monitor that. If you cannot reproduce your breath hold, you might get the wrong target,' he said.

Future development will need to take into account footprint, comparison of set-up time vs. manual adjustment. ■

Report: Mélisande Rouger

Image augmentation, interpretation and evaluation

AI for multimodality hybrid imaging: a diamond in the rough

AI-based models for multimodality hybrid imaging have the potential to be a potent clinical tool but are currently held back by a lack of transparency and maturity, says Dr Irène Buvat, from the Laboratory of translational Imaging in Oncology, Institute Curie in Paris, France. During a webinar of the European Society of Radiology, the expert provided a roundup on the benefits and current limitations of the technology.

'AI keeps growing' – publications in both radiology and nuclear medicine have seen a steep incline in the past years. These mostly focus on three applications: enhancement of image quality, acceleration or automation of image analysis, and discovery of new insights, for example, using predictive biomarkers. The use of AI for image enhancement and analysis has even moved beyond purely academic methods, with the first generation of commercially available products entering the market.

The new technology shows great potential. However, Buvat advises to proceed with caution: 'Having these AI methods available does not mean that they necessarily bring added clinical value.' Still, the expert believes that the extensive clinical evaluation of these methods can serve as a foundation to build upon.

Image augmentation: better looking, but less accurate?

One field where AI has already produced promising results is the recovery of high-quality images from low-count ("noisy") data, for example in PDG-PET imaging. 'We can train the algorithm to optimally filter the data, so decent images can be recovered even from low-count acquisitions.' In studies, nuclear medicine physicians rated the resulting images as superior, compared with standard Gaussian filtering. However, it was noted that standard uptake values (SUV) were underestimated in AI-denoised images, especially in smaller lesions. Another study, which focused on low-count SPECT imaging, found that the AI filter even lowered lesion detectability, compared with unaltered images. 'This is somewhat concerning,' says Buvat, urging her colleagues to keep this effect in mind when measuring SUV during patient follow-up.

Despite such shortcomings, Buvat acknowledges the huge potential of AI: 'If we can make these algorithms work, there would be substantial benefits: It would enable faster scanning and higher patient throughput, with less motion artifacts in the images. A second benefit would be in performing low-dose scanning, which can be extremely useful in paediatrics, or for the follow-up of patients using PET/SPECT scans. There could even be novel applications, a larger use of nuclear medicine procedures in children and also possibly, in pregnant women.' For example, researchers used FDG-PET/MR imaging to assess fetal radiation dose in the uterus at various stages of a pregnancy.

Image segmentation: (almost) on par with human experts

AI has also proved capable in the field of image interpretation, for example for automated segmentation. 'The good news here is that out-of-the-box solutions actually work quite well,' Buvat points out, citing as an example nnU-Net, a deep learning-based, self-configuring segmentation algorithm. The relevancy in the context of hybrid imaging becomes clear when the method is applied to cancer patients, where the AI will automatically segment lesions, for example in head and neck cancer. Current algorithms produce tumour delineations that range from satisfactory to almost indistinguishable from those of human experts – a promising application, the expert finds, even if some manual correction of results may still be necessary at this point.

Extending this method to whole-body imaging, recent algorithms have even tackled the challenge of multi-organ segmentation from PET/CT/MR scans – with equally impressive results. This could lead to several interesting applications, from automated tumour location and reporting to multi-organ metabolism measurements. 'We are entering the domain of systems medicine here, so this is extremely promising.' However, Buvat cautions that the AI-generated evaluation should still be closely scrutinised to avoid misleading results.

Gaining additional insights

Artificial intelligence can also be used to gather additional insights from diagnostic images. The creation of radiomic model for prediction and patient stratification is among the most frequent of these applications, the expert explains. For example, researchers used an AI to predict survival of Diffuse Large B-cell lymphoma (DLBCL) patients based on their PET/CT scan maximum intensity projection (MIP). 'When the scan is segmented by an AI, and the metabolic tumour volume is calculated, the stratification – which is fully automated – is very close to what is obtained by an expert.'

Combining radiomic and clinical information can also yield valuable insights into patient survival and recurrence rates from head and neck cancer. 'A nice asset of this model is that you can understand the factors that are related to recurrence-free survival,' Buvat says: This takes into account both clinical factors, such as tobacco use, and imaging features, for example maximum diameter of lesions and shows their impact, giving transparent results.

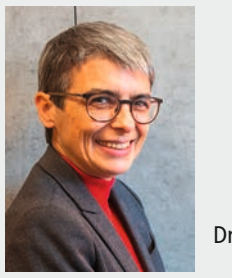
A major challenge at this point is the ability of the models to generalise. 'It has been shown that this is far from obvious,' the expert says. Often, the models' performance suffers significantly when confronted with new, external data. A potential solution for this issue is already in the wings, through harmonising the images and features used by the algorithm. Recent papers show that this approach is quite successful, achieving adequate results even with new data.

An assistant to trust in

Another roadblock for the adaptation of AI models lies within their lack of transparency. While calculation formula may be highly accurate, their cryptic appearance prevents the imaging experts from gaining an actual understanding about their working principle. 'When dealing with such models, it is impossible to understand what it means, and that means it is difficult to trust it, since we have no idea about what is going on. What we need are models that provide an explanation associated with the results.' For example, insights into the models' "black box" may be gained via attention and probability maps that show which region of a given image was used in the decision-making process. 'It has been shown that, when the readers are given the results of the AI and the explanation, the performance in detection is improved compared to when the readers are not assisted by the AI.'

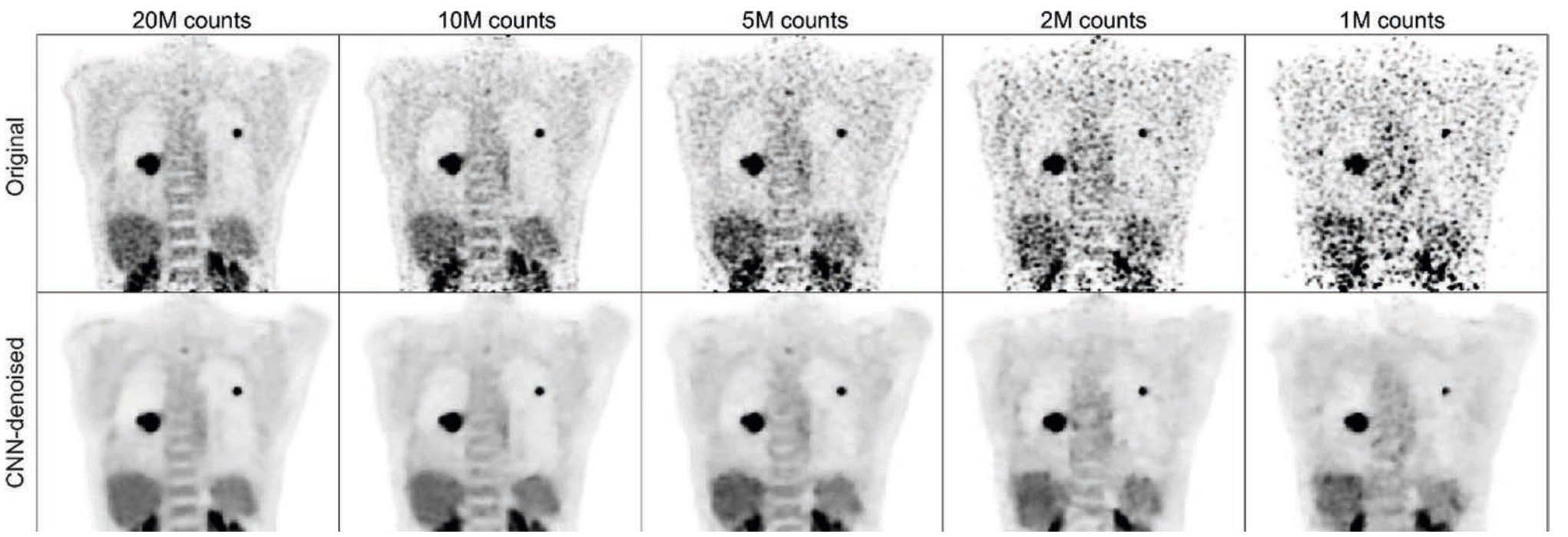
Buvat stresses that even with sophisticated algorithms at work, sometimes an image just does not hold sufficient information to answer a clinical question, for example to differentiate between different forms of neurodegenerative disease. Such limitations may be overcome using multimodal data integration. 'We have to account for more than just the hybrid imaging data,' the expert points out, citing clinical, pathological and genetic data as viable sources to complement imaging results. AI will play a crucial role in this task, she says: 'But, at this point, the AI-based methods have not yet reached sufficient maturity.' Clinical-task-based and multi-centre evaluation are still needed to thoroughly evaluate the models. If these issues are addressed, Buvat predicts a bright future for the technology, concluding: 'AI will ultimately make high-quality quantitative image interpretation commonplace and will help us discover new radiomic phenotypes associated with outcome.' ■

Report: Wolfgang Behrends



Dr Irène Buvat

Dr Irène Buvat is Research Director of the French National Centre for Scientific Research (CNRS) and heads the Inserm Laboratory of Translational Imaging in Oncology (LITO) at Institut Curie, Orsay, France. She is an expert in the development of quantification methods in molecular imaging using Emission Tomography. Her research focuses on developing and validating new biomarkers in Positron Emission Tomography.



Even with low-count image material, AI algorithms can generate decent results. In this example, after training completed, the convolutional neural network produced outputs with improved noise properties, relative to the original image volumes—inter-voxel spatial variance was reduced and anatomical boundaries were generally preserved. © Schaefferkoetter et al., EJNMMI Research 2020 (CC BY 4.0)

Disaster victim identification

Radiology in DVI: distressing insights and "hidden gems"

Identifying victims of major disasters remains a significant challenge for investigators. Often, identification can take weeks or longer, but new approaches are paving the way for greater accuracy and quicker identification whilst preserving the body without unnecessary invasive investigation.

In mass casualties or terrorist attacks, many victims need to be identified despite the possible extensive destruction of the bodies. Radiology has become essential in this process. More recently, greater use of 3D reconstruction which is harnessing CT to add a non-invasive dimension to disaster victim identification (DVI) might help overcome some of the challenges of DVI.

A session dedicated to DVI at ECR 2023 in Vienna heard how 3D imaging technology is building up pictures of victims and re-assembling body parts – often while the remains are still in the body bag – while also conducting investigations in a way that preserves the dignity of the victim. In turn, that offers reassurance to relatives that the investigation is being conducted in a humane and sympathetic manner.

Forensic pathologist Dr Mike Biggs, from the East Midlands Forensic Pathology Unit in Leicester in the UK, has been involved in a range of high-profile investigations. These included the MH17 incident (with the UK nationals involved); Shoreham Airshow crash; and the Grenfell Tower fire in London (where mobile CT scanning was used).

In cases where coroners specifically request non-invasive investigations, 3D imaging offers benefits. Biggs suggests there are 'hidden gems' of information contained in the DICOM data but that accessing it can at times be problematic, particularly where mobile scanners are used. 'You can answer specific questions if you are willing to extract data from DICOM,' he said. The 3D application has value in reconciliation of body parts, which may even be in different bags. 'The anatomy is not always in the right place and with fragmented bodies it can take time to work out what is going on. This is where the 3D application can be very helpful,' said Biggs.

He outlined how CT scanning of body bags can identify victims from distinctive jewellery or clothing and then start answering specific questions, with reliance on comparison of ante-mortem and post-mortem data to reach an identification.

The standard Interpol approach for DVI body reconciliation was outlined to delegates, with pink post-mortem paperwork and yellow ante-mortem data (fingerprints, dental records, DNA samples) following scene investigation to bring the elements together to obtain a positive identification.

In addition, pathologists are increasingly being asked by police to produce physical 3D prints for the courtroom, particularly when coroners want scan-only autopsies rather than invasive examinations. Biggs said the 3D software can clean-up images, removing vegetation, degradation, and insects, and produce sanitised colour images that are less distressing for jurors.

Powerful reconstruction and analysis possibilities

With fragmented bodies, the available tools can produce inventories of the bones that are present and absent, arrange them in presentation form, and reassemble them.

The expert recalled one example, where there were no dental records, and the individual was identified from a Facebook profile picture, with the help of a 3D print of the teeth which matched the victim. In another case, the technology reassembled the skull of an unidentified person to create a facial reconstruction and use that to put out an appeal for witnesses.

It is also possible to show the way forces propagated through a bone to identify what happened to cause a fracture. 'There is the potential for doing very useful analysis,' he added.

Preserving the integrity of the body

In introducing the session, radiographer and co-chair Mark Viner said DVI sat within the congress theme of "The Cycle of Life" and the medico-legal process of identifying the person who died 'so loved ones can grieve and begin the healing process.' This, he said, can be complex, particularly in mass fatality incidents with trauma, body fragmentation or decomposition and where reliance is on the hard tissues of bone and teeth that survive long after the soft tissues have gone.

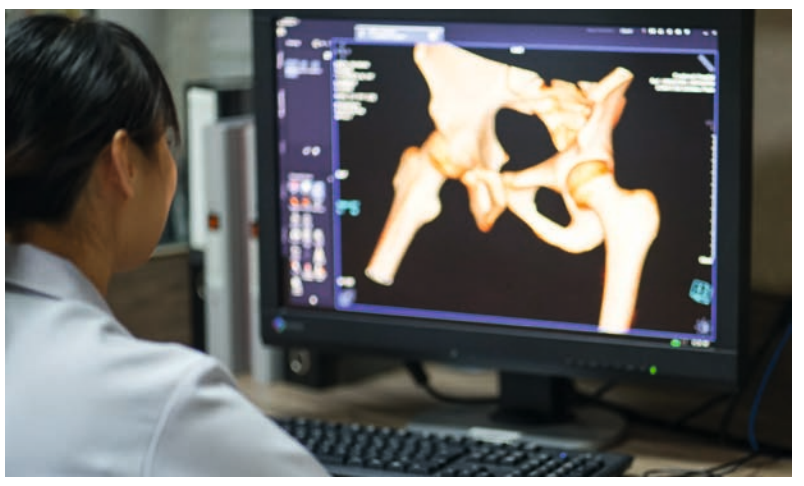
Radiology was first proposed for human identification as early as 1896 and first used in a mass fatality incident in 1949, with the non-invasive tool of CT coming to the fore more recently. 'This means we can we use technology to answer question of identity less invasively, preserving the integrity of the body for the loved ones. In recent years, mobile multidetector CT (MDCT) has become the gold standard for DVI investigations,' said Viner.

Shift from x-ray to CT imaging

The session also heard from Dr Arne Stray-Pedersen from Oslo, Norway, who discussed the role of radiology on victims of the 2011 terror attacks in Norway with a bomb explosion followed by mass shootings at a youth camp.

Thomas Ruder from Berne, Switzerland, meanwhile discussed the use of radiology in DVI, highlighting how whole-body CT in a post-mortem setting makes all structures of the body available to compare to ante-mortem images. 'The use of radiology for identification and DVI has seen a transition from x-ray to post-mortem CT, as we have seen in the clinical side of radiology. CT is much more versatile for identification.' The scenario and the conditions of an incident determine imaging modalities and roles as a biological and medical profile is established. 'Comparative radiologic identification is based on visual pattern recognition, which also plays a central role in clinical radiology,' said Ruder. ■

Report: Mark Nicholls



3D imaging technology is used to build up pictures of victims and re-assembling body parts. © pangoasis - stock.adobe.com

Sustainability in medical imaging

Reducing environmental pollution after contrast-enhanced scans

Radiologists called for action to reduce the release of contrast media in the hospital's wastewater after contrast-enhanced examinations in a dedicated session at ECR 2023.

An estimated 300 million CT examinations are being performed each year in the world. This number is expected to grow, and with it, the amount of iodinated contrast media (ICM) used in radiology, according to Professor Olivier Clément, Head of Imaging at Georges Pompidou European Hospital in Paris, France, and Chair of the contrast media committee of the European Society of Urogenital Radiology (ESUR). 'If you assume that 40% of CT scans are being carried out with an average of 100ml of contrast media, you end up with 12 million litres of ICM that are being injected in patients and then evacuated in the sewage,' he told the audience in Vienna. This contamination of the aquatic environment is being increasingly studied. In Germany, for example, about 200 kg of contrast media are released in the Rhine river every day. 'That means 70.9 tonnes per year. It's a lot and it means that we can really recover ICM from the aquatic environment,' he said.

Twelve million litres of iodinated contrast media (ICM) are being injected in patients and then evacuated in the sewage worldwide every year.
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Appeal for a more patient-tailored approach

There are also review studies about contrast media's effects on the environment. In a paper published in the Science of the Total Environment in 2021, a team of Indian researchers found that, whatever the contrast media used, a large amount was found not just in hospitals' sewage waste water but also in surface, ground and drinking water in North America, Asia and Europe. 'It's a global problem, a world issue of contamination of surface and drinking water due to contrast media release,' he said. The contribution of ICM to water pollution can be as high as 80% in the mass loading of pharmaceuticals in a hospital's effluent, because of the amount of ICM that is being injected, he went on. 'When we inject antibiotics, we inject up to three grammes per patient. But when we inject ICM, we inject up to 45 g per patient so the mass of CM is much higher.' The expert stressed that in themselves, ICMs are not dangerous – the danger comes from the disinfection process in the treatment plants, which use chemicals such as chlorine and chloramine. These products create toxic iodinated disinfection by-products (IDBPs) that can be found in the aquatic environment and drinking water. 'This is really the environmental problem of using contrast media,' he said.

Radiologists should be aware of the issue and work to decrease pollution linked with ICM use. 'First we should inject less contrast media and respect the indication, i.e., always inject dose which is related to weight, especially for oncologic imaging,' he suggested. 'We should reduce waste and use the adequate vial for the patient, i.e., open a vial of 100 ml when we use 90 and not a vial of 150. We should also recycle the residue in the vial.'

Taking steps is also important because of the high demand for ICM all over the world. 'Vendors can produce a certain amount of ICM per year that isn't even sufficient for all the examinations,' Clément said. 'So, we must think of how we use these products and find new ways to inject less contrast, with low kV and AI for example.' Although software solutions are being trained to reduce ICM dose, a small amount of contrast media remains necessary to actually create contrast in the image, he believes. 'We will still need contrast media in radiology for a long time.'

Strategies to reduce pollution include releasing ICM in hospital circuits linked with specific plants, installing dry toilets for patients who have undergone a contrast-enhanced examination, and collecting urine in bags to be incinerated, since incineration is less polluting than using ICBPs to purify the water. 'The radiology community should be aware of the huge amount of iodine contrast media released in the environment,' he concluded. 'We should inject wisely, know about toxic IDBPs in plants and take specific measures to decrease the effluence.'

Surprisingly high 'green sensitivity' in patients

Iodine contrast media are not the only source of concern when it comes to residuals in hospitals' wastewater. About 50 million of gadolinium-based contrast agents (GBCA) doses are being injected per year and then evacuated in the sewage, according to Professor Francesco Sardanelli, Director of the Department of Radiology at the Research Hospital (IRCCS) Policlinico San Donato in Milan, Italy, where the Greenwater study was recently launched. As previously reported, the project aims to evaluate the extent of retrievable ICM and GBCA from the urine collected after CT and MRI scans, and to assess patient acceptance to participate in the study – the 'green sensitivity'. The study was carried out with urine collection within 60 minutes of administering the contrast agent, so about 30 minutes after the examination. Results have been both surprising and encouraging, Sardanelli explained. 'The first unexpected finding to me was the high acceptance from patients,' he said. '94% of them agreed to take part in the study and stay half an hour more in the department. That means that we can go in this direction quite effortlessly.'

The fact that patients wanted to cooperate in the project is very good news for manufacturers and hospitals, he added. 'It shows patients are highly sensitive to sustainability. Even in a hectic city like Milan, people took the time. We have to use this availability.' The future is to recycle both iodine and gadolinium agents, by creating virtuous cycles in which the product comes back to the producer after it has been injected in the patient. 'That would make sense,' he concluded. 'Recycling is the solution.' ■

Report: Mélisande Rouger

Olivier Clément

Olivier Clément is Professor of Radiology at Descartes Paris University and Head of Imaging at Georges Pompidou European Hospital in Paris, France. He is also Chair of the contrast media safety committee of the European Society of Urogenital Radiology (ESUR).

Francesco Sardanelli

Francesco Sardanelli is Professor of Radiology at Milan University and Director of the Department of Radiology at the Research Hospital (IRCCS) Policlinico San Donato in Milan, Italy.

Project EU-JUST-CT

CT scans: systematic evaluation of benefits and risks

When is a CT scan justified, i.e. when do the benefits of a CT scan for the patient outweigh possible risks associated with radiation? Justification has been a major issue among radiologists ever since CT has become widely available and widely used. With regard to dose the answer is the well-known ALARA principle: 'As low as reasonable achievable'. Now, the European coordinated action on improving justification of computed tomography (EU-JUST-CT) has a closer look at the process of justification. At ECR in Vienna, initial results were presented.

According to the EU legal framework, the use of radioactive substances or ionizing radiation in human beings requires a justified indication that must be provided by a medical expert. This principle is confirmed in the EU Basic Safety Standards Directive (BSSD) which demands that any imaging examination that causes radiation exposure has to be justified in a standardized process prior to the exam.

The EU member states were asked to adopt appropriate regulations. 'Appropriate justification and optimization of all procedures involving patient ionizing exposure are essential elements of good and safe clinical practice,' underlines EU-JUST-CT's lead researcher Professor Dr Boris Brkljačic of the School of Medicine at the University of Zagreb. At this year's ECR, Professor Brkljačic presented interim results of the project which started on 7 April 2021 and is scheduled to run until March 2024.

Two project goals have already been reached

Two of EU-JUST-CT's four goals have already been reached. A survey to collect up-to-date information about justification of CT examinations in Europe was conducted in 145 centers in seven EU countries. And indeed the survey results confirmed the need for action. In Luxembourg, for example, a study showed that 39 percent of the CT scans requested by referring physicians were uncalled for.

In 35 percent of the cases, the clinical justification was so vague or incomplete that the necessity of the requested CT scan could not be properly assessed.

The second goal, the development of a common methodology for auditing justification of CT examinations, has also been completed. A third goal will be achieved shortly: coordinated pilot audits of justification of CT examinations in a minimum of five different European countries.

Discussion with the Member States

The fourth and final phase is ahead, namely the discussion of the status of justification of CT examinations with the member states and identifying opportunities for further action. This entails initiating the legal implementation of the justification audits that were developed. One focus will be CT scans of children and adolescents. 'The role of CR

It must be considered very carefully whether the benefits of a CT scan outweigh the potential dangers to the patient due to radiation. © pressmaster - stock.adobe.com

examinations is undisputed, thanks to the diagnostic information provided in countless clinical conditions. However, in the past years a few epidemiological studies raised concerns about its use in children, as CT studies were linked to an increase in the risk of brain tumours,' Brkljačic points out.

This includes an analysis of the EPI-CT cohort study which was recently published in Lancet Oncology. It found that one of 10,000 young patients developed a brain tumour five to fifteen years after a head CT scan.

Major impact on the healthcare system

Brkljačic is convinced that these results will have a major impact on the healthcare systems and on the debate of the justification of CT scans. ■

Report: Michael Krassnitzer

EU-JUST-CT is led by the European Society of Radiology (ESR) and has received funding from the European Commission

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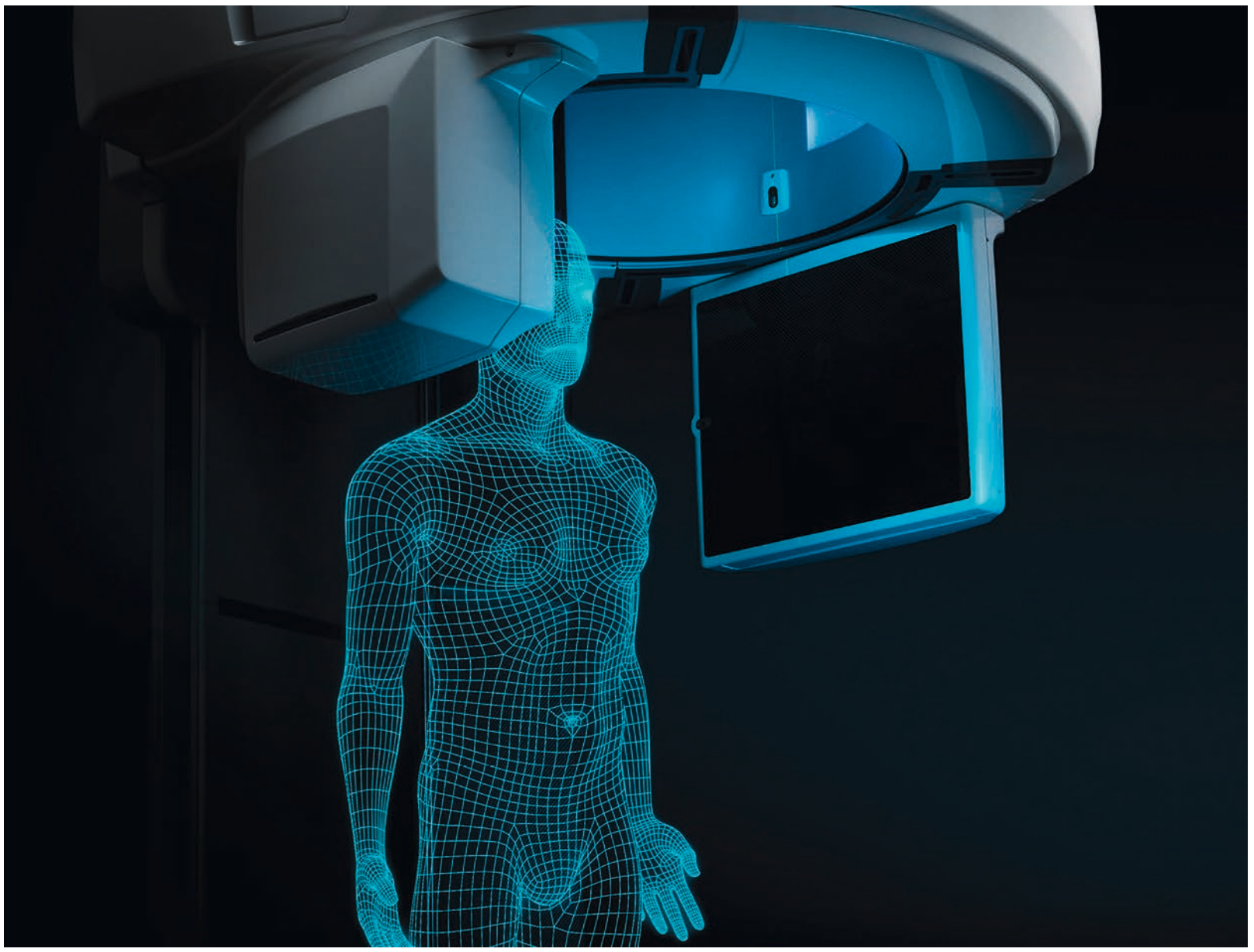
A replacement for multidetector CT?

Discussing the benefits of cone beam CT

Radiology practitioners have highlighted the benefits of cone beam CT in delivering high resolution at a low dose. Delegates at ECR 2023 in Vienna heard how cone beam CT (CBCT) could replace multidetector CT (MDCT) in some areas and is already showing cost-effectiveness benefits.



Cone beam CT can deliver high resolution at a low dose. © Planmed

The aim of the session, entitled "High resolution at low dose: where and why cone-beam CT will replace multidetector CT", aimed to offer an understanding of the technical principles, advantages and limitations of CBCT and where it outperforms MDCT. Current clinical applications were presented with a specific focus on the utility of CBCT in daily practice.

Expanding applications

Medical physicist Mika Kortesniemi, Adjunct Professor and Chief Physicist in the Department of Medical Imaging at the University of Helsinki, Finland, outlined the technical principles, dose and artefacts of CBCT, looking at advantages and disadvantages. 'There are many applications and they are expanding in certain clinical indications,' he said. 'That includes dental and ear, nose and throat (ENT) radiology, and also for radiotherapy on-board imaging for verification of treatments.'

The technique is also seeing applications in interventional radiology, rotational angiography, and physical extremities in musculoskeletal (MSK) imaging, with the emerging value of the 3D beam becoming clearer. 'CBCT can also be used in various orientations,' Kortesniemi continued. 'We can do weight bearing imaging for extremities, bringing added value on how the tissue structures behave under pressure of the gravitational force.'

Meaningful data and other benefits

CBCT technology is smaller and easier to install in a clinical setting with associated cost benefits as compared to MDCT, the expert pointed out. In addition, when compared to traditional 2D imaging, CBCT can offer 'supplementary and often much more diagnostically meaningful data.' On the other hand, he also acknowledged technical and physical shortcomings, with limited field of view and issues of heterogenous radiation dose distribution within the area that is imaged.

Dr Mika Kortesniemi

Dr Mika Kortesniemi works as the Chief Medical Physicist and Adjunct Professor at the HUS Diagnostic Center, University of Helsinki and Helsinki University Hospital, Finland. His professional, teaching and research focus is on the quality assurance, radiation dosimetry, optimisation, and radiation protection in x-ray imaging, especially related to the computed tomography and utilisation of artificial intelligence. Dr Kortesniemi is also actively involved in international collaboration with IAEA, ICRP, EFOMP and ESR.

Kortesniemi highlighted the higher resolution with lower dose, pointing to Voxel sizes down to 0.1 mm and with a scalable field of view from 2–26 cm and the potential to scan the whole head, with scanners being developed capable of covering larger body regions. With the flat panel detector technology, he noted that gantry weights vary from about 60kg to more than 600kg.

Potential for optimisation

He said there are a limited number of projections for the raw data CBCT acquires, especially compared to multi-slice CT, which has much more projections to a rotation. The lower number of projections, in combination with limited field-of-view, means a decrease in low or soft tissue contrast and there is a longer scan time of 10–30 seconds, during which patients may move.

Most CBCT scanners use short radiation pulses rather than continually exposing patients during gantry rotation, and reconstruction time is getting shorter due to more efficient techniques, with a move towards AI-based image reconstruction. 'One of the key optimisation strategies in CBCT is to optimise the field of view to the minimum needed for a diagnostic question,' he said. 'A range of different field of views have direct impact on the patient dose.'

Will technology make artifacts a thing of the past?

Artifacts – caused from metals in dental implants, for example – are an issue to consider with CBCT, Kortesniemi added. These can cause additional scatter and beam hardening. He believes that evolving image calculation and reconstruction techniques will provide better means to correct these artifacts, which may also be caused through patient movements, to improve the overall image quality.

The expert said DAP (dose area product) provides a simple and robust dosimetry unit for CBCT and avoids scatter problems in measurement. Comparing CBCT to MDCT, he said CBCT had lower performance in terms of scan time, soft tissue contrast and clinical applications, but had positives in terms of cost, required area, patient dose – to some extent – and spatial resolution.

'The method of choice' for head and neck region

Following up, Professor Bert De Foer, from the GZA Hospitals in Antwerp, Belgium, spoke about current clinical indications for CBCT in the head and neck, discussing its use in sinonasal, dental and temporal bone imaging. He said with CBCT, most patients are sitting upright and the X-ray source is turning around the patient and scanning on flat panel. Disadvantages of CBCT include poor soft tissue resolution, limited scan range, motion artefacts, and the process is time consuming.

However, Professor De Foer, who is also President of the European Society of Head and Neck Radiology (ESHNR) and chaired the session, added: 'I have replaced MDCT by CBCT in the head and neck area for temporal bone, sinonasal and dental imaging since 2011 in my department and it is definitely the method of choice to do CT examinations in the head and neck region, due to its very high spatial resolution, low dose and equal quality of images in all planes.'

Professor Bert De Foer

Professor Bert De Foer is a consultant radiologist at the department of Radiology of the St Augustinus Hospital, GZA Hospitals in Antwerp, Belgium, and responsible for Head and Neck and Neuroradiology. He is president of the ESHNR and has a current scientific interest in the field of the value of MRI in the diagnosis of Ménière's disease.

'A choice for quality and lower radiation'

Sana Boudabbous from the Faculty of Medicine at the University of Geneva, Switzerland, focussed on CBCT in morphologic and functional MSK imaging. She said: 'It gives 3D imaging with high quality, high resolution, weight bearing position is first advantage of this technique for many diseases for lower limbs and lower dose than conventional CT. The future will be reduced contrast, use of dual energy and bone quantification for example in osteoporosis.'

In closing the session, De Foer said: 'I hope we have been successful in proving that CBCT is something completely different from MDCT and there is definitely a place for CBCT in modern radiology departments. It is a choice for quality and lower radiation.' ■

Report: Mark Nicholls