Check for updates

Exploration

Exploration

PERSPECTIVE OPEN ACCESS

Next-Generation Surgery: Integrating Artificial Intelligence, Genetic Technologies, Bioengineering and Rehabilitation Into Modern Practices

Dengxiong Li[1,2] | Jie Wang[2] | Zhipeng Wang[3] | Ruicheng Wu[2] | Zhouting Tuo[4] | Fanglin Shao[5] | Wenjing Ge[6] | Ziyu Shu[7,8] | Yubo Yang[9] | Dilinaer Wusiman[10,11] | Qingxin Yu[12,13] | Luxia Ye[14] | Alisha Pati-Alam[15] | Facai Zhang[16] | Koo Han Yoo[17] | Susan Heavey[15] | William C. Cho[18] | Dechao Feng[15,16]

[1]Department of Urology, The First Affiliated Hospital of Zhejiang Chinese Medical University (Zhejiang Provincial Hospital of Chinese Medicine), Hangzhou, Zhejiang Province, China | [2]Department of Urology, Institute of Urology, West China Hospital, Sichuan University, Chengdu, China | [3]Department of Urology, Sichuan Provincial People's Hospital, University of Electronic Science and Technology of China, Chengdu, China | [4]Department of Urology, Tianjin Institute of Urology, The Second Hospital of Tianjin Medical University, Tianjin, China | [5]Department of Rehabilitation, The Affiliated Hospital of Southwest Medical University, Luzhou, P.R. China | [6]Department of Clinical Neurosciences, University of Cambridge, Cambridge Biomedical Campus, Cambridge, UK | [7]Department of Earth Science and Engineering, Imperial College London, London, UK | [8]Joint International Research Laboratory of Green Buildings and Built Environments (Ministry of Education), Chongqing University, Chongqing, China | [9]Department of Urology, Three Gorges Hospital, Chongqing University, Wanzhou, Chongqing, China | [10]Department of Comparative Pathobiology, College of Veterinary Medicine, Indiana, USA | [11]Purdue Institute for Cancer Research, Purdue University, West Lafayette, Indiana, USA | [12]Department of Pathology, Zhejiang University School of Medicine, Research Unit of Intelligence Classification of Tumor Pathology and Precision Therapy, Chinese Academy of Medical Sciences, Hangzhou, Zhejiang, China | [13]Department of Pathology, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China | [14]Department of Public Research Platform, Taizhou Hospital of Zhejiang Province Affiliated to Wenzhou Medical University, Linhai, China | [15]Division of Surgery & Interventional Science, University College London, London, UK | [16]Urology & Nephrology Center, Department of Urology, Clinical Medicine Research Institute, Zhejiang Provincial People's Hospital(Affiliated People's Hospital), Hangzhou Medical College, Hangzhou, Zhejiang, China | [17]Department of Urology, Kyung Hee University, Seoul, South Korea | [18]Department of Clinical Oncology, Queen Elizabeth Hospital, Hong Kong, China

Correspondence: Koo Han Yoo (yookoohan@khu.ac.kr) | Susan Heavey (s.heavey@ucl.ac.uk) | William C. Cho (williamcscho@gmail.com) | Dechao Feng (dechao.feng@ucl.ac.uk)

Received: 13 November 2024 | **Revised:** 31 July 2025 | **Accepted:** 26 November 2025

Keywords: artificial intelligence | bioengineering | clinical practices | genetic technologies | next-generation surgery | rehabilitation

ABSTRACT

Surgery has undergone a transformation in recent decades, from open operations to minimally invasive surgery. Significant advancements in technologies like robotic and minimally invasive techniques have led to better outcomes. However, simply enhancing anatomical knowledge and surgical skills has left the field of surgery stuck in a rut. Challenges like cost, training, patient safety, ethics, and global disparities persist. In the knowledge-explosion era, surgical methods have been advanced by the integration of multidisciplinary cutting-edge technologies like artificial intelligence (AI), genetic technologies, bioengineering, and elaborative rehabilitation scheme. Surgeons can more effectively and efficiently handle complicated clinical difficulties, optimize surgical operations, and provide individualized therapies by utilizing the combined power of these technologies, paving the way for reshaping contemporary surgical practices. Here, we overview how these key technological advancements have brought about the advent of "next-generation surgery."

Dengxiong Li, Jie Wang, Zhipeng Wang and Ruicheng Wu contributed equally to this work.

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.
© 2026 The Author(s). *Exploration* published by Henan University and John Wiley & Sons Australia, Ltd.

1 | Introduction

Surgery is on the verge of a technological revolution, with cutting-edge techniques changing established practices [1]. From antiquity through the Middle Ages, surgery remained primarily open procedures performed with rudimentary tools following high mortality rates. The 19th century breakthroughs in anesthesia and antisepsis established modern surgical foundations, while 20th-century advances in medical imaging and life support enabled complex procedures like organ transplantation. Contemporary surgery integrates minimally invasive techniques, robotic systems, artificial intelligence (AI) navigation, and precision medicine, driving the field toward intelligent, personalized, and remote-controlled approaches. There are concepts and techniques proposed to improve surgical skills and treatment outcomes [2]. These concepts and techniques include minimally invasive surgery, robotic-assisted surgery, augmented reality (AR) and virtual reality (VR) technologies, enhanced recovery after surgery (ERAS) protocols, telemedicine and remote surgery, tissue engineering and regenerative medicine and simulation-based training, which also play significant roles in improving and advancing surgical procedures [3, 4]. In addition, surgeons increasingly specialize in specific areas, such as neurosurgery, cardiothoracic surgery, orthopedic surgery, urology surgery and so on [5]. This specialization leads to deeper expertise and more targeted treatments. Interdisciplinary collaboration is also more common. Surgeons frequently collaborate with other medical professionals, including radiology, oncology, and anesthesia, to give complete care to patients [6, 7]. Multidisciplinary teams contribute to more effective treatment strategies and outcomes. Moreover, access to surgical care varies worldwide, with some areas lacking suitable facilities, equipment, and qualified workers [8]. Efforts are underway to increase global access to critical surgical treatments, particularly in low- and middle-income nations.

However, surgery is a rapidly evolving field that faces challenges. Advanced surgical procedures and technologies can be costly, which presents issues for healthcare organizations, particularly in resource-constrained areas [8]. Many patients continue to face major financial and accessibility barriers to surgical care. In addition, surgeons need to undergo extensive training and continuous education to maintain proficiency and stay up to date with innovations [9]. It is imperative to guarantee that surgeons have access to adequate training opportunities and resources, particularly in developing fields [10]. Access to timely and high-quality surgical care is still unevenly distributed across and within nations, with rural and marginalized populations frequently encountering more obstacles in this regard. Reducing these disparities calls for coordinated efforts at the infrastructure, funding, and policy levels. In terms of patient safety, surgical operations are inherently risky due to the possibility of bleeding, problems from anesthesia, and infection, even with modern technological developments [11]. It is a never-ending challenge to ensure patient safety through strict protocols, standardized practices, and quality improvement activities. On the other hand, careful thought is needed to preserve patient autonomy, beneficence, and justice when it comes to ethical conundrums in surgery, such as end-of-life decisions, organ transplantation, and experimental treatments [8, 12].

Overall, even though surgery has significantly improved patient outcomes and quality of life, successive efforts are required to address these issues and guarantee that patients have fair access to surgical care. Breakthroughs in surgical technology have transformed operations from focusing solely on preoperative preparation and intraoperative procedures into a systematic continuum spanning from outpatient care to complete postoperative recovery. This evolution demands surgeons' comprehensive understanding of next-generation surgical approaches to advance the field. Accordingly, this article examines potentially transformative technologies and discoveries, including AI, genetic technology, bioengineering, and rehabilitation, that may significantly reshape future surgical practice.

2 | Artificial Intelligence in Surgery

AI proves to be a potent ally in the field of surgery, utilizing autonomous systems, predictive analytics, and image recognition to enhance human talents [13, 14]. From preoperative planning to intraoperative decision-making and postoperative care, AI algorithms use big data to improve surgical results, reduce risks, and increase patient safety [15, 16].

2.1 | Preoperative Planning

AI algorithms help surgeons with preoperative planning by analyzing patient data such as test results, electronic health records, and medical imaging. This aids in figuring out possible issues, improving surgical techniques, and comprehending the anatomy of the patient. For instance, in the emergency department, significant time is often spent on preoperative tests, electronic health records, and medical imaging [17]. Thus, critical information may be overlooked due to the urgency of patient cases. A hybrid neural network-based AI model could predict whether trauma patients require specialized surgical intervention within 12 h of hospital arrival, aiding clinicians in timely decision-making [18]. Regarding routine surgery, AI can short the time of flap design in breast reconstruction by analyzing deep inferior epigastric perforator artery in CT data [19]. With the assistance of AI, surgical procedures can become safer and more efficient [20]. Therefore, AI can assist doctors in determining surgical necessity and optimizing operative schedules. This facilitates enhanced preoperative preparation for patients while expanding clinical decision-making options. Particularly in emergency settings, such AI-supported triage helps prevent the oversight of surgical patients.

2.2 | Image Analysis

Medical images such as magnetic resonance imaging, computed tomography scans, and X-rays can be accurately analyzed by AI algorithms with astonishing precision [21, 22]. In order to help surgeons make educated judgments during procedures, AI can help evaluate these images to identify anomalies, tumor margins, and crucial structures. For instance, AI analyzes preoperative CT scans of lung cancer patients to determine the presence of lymph node metastasis. This assists in identifying key areas and

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

the quantities of lymph nodes to be resected during surgery [23]. Mei et al. [24] developed an AI model using CT urography images to predict perirenal fat adhesion in renal cell carcinoma, improving surgical accuracy and efficacy. Moreover, AI-driven preoperative MRI analysis can evaluate the clinical characteristics of rectal cancer before operation, including extramural vascular invasion, lymph node metastasis, and T-stage classification [25]. Additionally, AI-integrated imaging can assess the tumor microenvironment, thereby predicting malignancy potential and treatment response [26]. These findings suggest that AI may leverage imaging data to provide critical clinical information for surgical planning and perioperative preparation, thereby establishing a robust foundation for comprehensive patient care throughout the treatment cycle.

2.3 | Robot-Assisted Surgery

AI-driven surgical robots, like the da Vinci Surgical System, provide doctors more accuracy and dexterity while performing minimally invasive treatments. These robots improve surgical outcomes and shorten patient recovery times by filtering hand tremors, scaling down movements, and providing 3D visualization [27]. In the endoscopy field, endoscopic retrieval of esophageal squamous cell carcinoma assisted by AI demonstrates higher sensitivity and specificity compared with the control group, without adverse event observed [28]. Another multicenter RCT also demonstrated that AI-assisted endoscopy significantly improved the detection rate of early esophageal squamous cell carcinoma, reduced missed diagnoses, and maintained acceptable safety profiles [29]. Although AI assistance can significantly improve surgical precision and reduce procedural difficulty, current AI-assisted surgical robots remain incapable of replacing human surgeons to operate independently. This limitation exists because each patient's anatomical structure and pathological alterations are unique, frequently requiring intraoperative judgment to determine surgical margins and preserve normal physiological structures. An erroneous decision could lead to surgical failure and life-threatening consequences. Furthermore, liability issues regarding unexpected accidents caused by autonomous AI-assisted surgical robots remain unresolved. Therefore, current AI systems are not yet capable of independent surgical operation.

2.4 | Decision-Making Assistant Systems

DuCRring procedures, surgeons can receive real-time guidance from AI-based decision support systems. These systems provide recommendations on the best surgical techniques, instrument selection, and possible dangers based on the analysis of data from multiple sources, such as imaging devices, surgical instruments, and patient vitals [30]. In an 80-year-old woman diagnosed with pancreatic cancer, the surgeon utilized SYNAPSE VINCENT, a 3D image analysis-based deep learning algorithm, for intraoperative navigation during partial pancreatic tumor resection [31]. The patient presented with lesions close to the pancreatic head, posing surgical challenges. This technology aids surgical personnel by providing anatomical guidance, displaying the thickness, volume, and precise location of the resecting pancreas, and facilitating real-time information sharing within the surgical team. Ultimately, guided by this system, the surgical team successfully excised the tumor, preserving pancreatic tissue, with the frozen section confirming negative surgical margins. This demonstrates the significant role of integrating AI algorithms and imaging intraoperatively. Similarly, Chen et al. [32] developed an AI laparoscopic exploration system that enabled real-time intraoperative detection of abdominal metastases during gastric cancer procedures. The system demonstrated comparable performance to novice surgeons in identifying abdominal metastases, with superior capability in detecting subtle and occult lesions. These demonstrate AI's potential to offer evidence-based guidance for individualized surgical decision-making.

2.5 | VR and AR Technologies

Surgeons may practice surgical methods, model difficult procedures, and view patient anatomy in three dimensions with the help of AI-powered VR and AR technologies. These virtual experiences reduce errors during actual surgeries, improve spatial awareness, and augment surgical training. In a renal cancer clinical study, combining the da Vinci surgical robot with 3D virtual models based on convolutional neural networks for robot-assisted partial nephrectomy aids surgeons in avoiding blood vessels, excising tumors, and preserving renal units [33]. This illustrates the potential practical applications of VR and AR in surgery and patient education.

2.6 | Predictive Analytics

AI algorithms are able to anticipate surgical results, postoperative complications, and patient recovery trajectories by analyzing large volumes of patient data [34, 35]. Surgeons can thus better tailor treatment regimens, reduce risks, and streamline patient care processes. For example, AI can automatically score pathological tissue stains from prostate cancer patients to predict survival prognosis [36]. Consequently, physicians can develop personalized postoperative treatment and follow-up plans based on patient prognosis, particularly drug responses, thereby enhancing therapeutic outcomes and optimizing comprehensive patient management.

2.7 | Natural Language Processing (NLP)

NLP approaches help extract and analyze information from unstructured clinical notes, research papers, and medical literature. Surgeons can use NLP-powered tools to retrieve relevant clinical knowledge, stay current with research findings, and make evidence-based decisions. Noord et al. reported that TLDR, an AI model, can read and summarize the content of medical papers in a sentence [37]. This function provides busy surgeons with summaries of the latest developments in the field and offers solution to intraoperative challenges through AI literature retrieval.

2.8 | Remote Monitoring and Telepresence

With AI-enabled telepresence systems, surgeons can remotely observe procedures, guide less experienced colleagues, and cooperate with diverse teams across geographic borders. This improves access to specialized care and encourages knowledge

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

sharing among surgeons worldwide. Doctors and patients can guide patient diagnosis and treatment through remote conversations [38]. Remote surgery is also being gradually conducted and has been successful [39]. Therefore, AI-assisted summarization of patient conditions by doctors and remote surgical guidance among doctors is highly anticipated direction. However, we need to notice that a surgical robot is the basis of remote surgery. While the costs of surgical robot procurement and utilization will ultimately be borne by patients, this does not necessarily increase expenses for all patients in underdeveloped or developing regions. Remote surgery should be reserved for patients whose local surgical teams lack capability or experience, rather than for routine surgeries. For these selected surgeries, remote surgery offers two key advantages: (1) eliminating the need for patients to travel abroad or domestically for specialized surgeries; and (2) reducing associated travel, accommodation, and follow-up expenses. Although the direct medical costs may increase, the overall treatment expenditure could potentially decrease when considering the entire care cycle—a hypothesis requiring further clinical validation. Regardless, AI-enhanced remote surgery provides underdeveloped regions with access to advanced medical care, representing a valuable area for exploration and development.

While AI has enormous potential for improving surgical practice, it is critical to address issues such as data privacy, regulatory compliance, and ethical considerations to ensure its safe and responsible integration into clinical processes. As technology advances, AI has the potential to improve surgery by improving patient outcomes, boosting surgical innovation, and pushing the frontiers of what is physically achievable.

3 | Genetic Technologies Revolutionizing Surgical Interventions

The emergence of genetic technologies heralds a new era of precision medicine, in which surgical procedures are tailored to each patient's particular genetic composition. Genomic sequencing, gene editing, and pharmacogenomics enable surgeons to interpret hereditary predispositions, tailor treatment regimens and reduce adverse effects, ushering in a new era of personalized surgical care [40]. Genetic technologies are revolutionizing surgical operations in a variety of ways, most notably by delivering personalized insights into patients' genetic makeup and illness risk [41].

3.1 | Precision Medicine

Genetic testing enables surgeons to customize treatment schedules based on a patient's genetic profile [42]. For instance, mutations in the CDKN2A significantly increase the risk of familial melanoma. Consequently, screening for the CDKN2A mutation allows surgeons to determine a patient's susceptibility to familial melanoma and recommend more frequent skin examinations and early surgical interventions [43, 44]. Surgeons can predict susceptibility to specific diseases, assess drug responses, and personalize treatment strategies to maximize efficacy while minimizing side effects by analyzing an individual's genetic variations.

3.2 | Risk Assessment and Screening

Genetic screening detects people who are at high risk of developing hereditary disorders like breast cancer, bladder cancer, and cardiovascular disease [45, 46]. Surgeons can use these data to implement preventive strategies, recommend screening procedures, and perform prophylactic surgeries as needed to reduce disease load and enhance patient outcomes. For example, mutations in the BRCA1 and BRCA2 substantially increase the risk of breast and ovarian cancer in patients [47, 48]. Individuals with BRCA1/2 mutations may choose prophylactic mastectomy, prophylactic oophorectomy, or more intensive monitoring strategies [49]. Furthermore, aortic dissection and other related aortic diseases often have a genetic basis, including mutations in the FBN1 associated with Marfan Syndrome [50, 51]. This proactive approach can manage and minimize the need for emergency surgery, optimizing treatment pathways and patient outcomes. This strategy enables early-stage disease control, decreasing both physical and psychological harm to patients and reducing associated economic and societal burdens.

3.3 | Pharmacogenomics

Pharmacogenomic testing investigates genetic variations that affect drug metabolism and reaction [52]. For example, mutations in the VKORC1 and CYP2C9 significantly influence warfarin metabolism. This genetic testing enables surgeons to select the appropriate anticoagulant medication and initial dosage to minimize the risk of bleeding during surgery or thrombosis postoperatively [53]. Moreover, certain genetic variations can result in poor responses to specific analgesics. For instance, screening for the OPRM1 can predict a patient's response to morphine, enabling tailored pain management strategies that ensure adequate postoperative pain control while avoiding overmedication and associated side effects [54, 55]. Surgeons can use this information to optimize medicine selection, dosage modifications, and reduce the likelihood of adverse drug reactions during the perioperative period, thus improving patient safety and postoperative recovery.

3.4 | Targeted Therapies

Tumor genetic screening allows surgeons to pinpoint precise molecular targets responsible for cancer growth [56]. For example, in the treatment of NSCLC, patients with EGFR mutations can benefit from EGFR inhibitors like gefitinib or erlotinib, which generally yield fewer side effects than traditional chemotherapy [57]. This knowledge enables the selection of targeted medicines, immunotherapies, or precision surgical procedures suited to the individual's tumor biology, hence increasing treatment efficacy and survival results in cancer patients.

3.5 | Gene Editing and Gene Therapy

Novel genomic technologies, like CRISPR-Cas9, enable accurate manipulation of the human genome, providing prospective treatment options for genetic illnesses and hereditary diseases [58].

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

For instance, studies have shown that dendritic cells edited by CRISPR-Cas9 can accelerate wound healing via growth factor signaling pathways, significantly altering fibroblast gene expression in the wound bed [59]. A phase 2 trial, identified that NTLA-2002, a CRISPR-based vivo gene-editing therapy, could significantly depress angioedema attacks [60]. Surgeons may employ gene editing techniques in the future to improve wound healing, repair damaged tissues, and correct genetic defects, opening the door to novel surgical procedures and regenerative medicine strategies.

3.6 | Biomarker Discovery and Prediction

The identification of novel biomarkers linked to the course, prognosis and response to therapy of diseases is made possible by genetic technologies [61]. In prostate cancer, prostate-specific antigen (PSA) levels enable surgeons to stratify patients by risk, thus guiding the development of tailored treatment plans. Surgeons can also use PSA to detect early tumor residues and recurrences, enabling rapid adjustments to treatment strategies [62]. By incorporating biomarker data into prognostic evaluations, patient counseling, and clinical decision-making, surgeons can maximize surgical outcomes and guide treatment decisions.

3.7 | Inherited Disease Management

Genetic testing makes it easier for patients with inherited conditions, like familial polyposis syndromes or hereditary heart diseases, to receive an early diagnosis, family screening, and prompt intervention strategies, like preventive surgery, lifestyle changes or focused surveillance protocols, to reduce the risk of these condition and improve long-term outcomes. For instance, in managing hereditary heart diseases like Marfan syndrome, detecting mutations in the FBN1 facilitates early diagnosis and monitoring, enabling preventive cardiac surgery when necessary [50, 51]. Effective prenatal monitoring and screening enable early intervention, significantly reducing developmental abnormalities caused by inherited diseases and their long-term health impacts, thereby lowering societal healthcare burdens.

3.8 | Genomic Data Integration

Surgeons are empowered with full patient information through the integration of genomic data into electronic health records and surgical decision support systems. This allows for data-driven clinical insights, risk stratification, and evidence-based treatment planning customized to each patient's genetic profile.

Leveraging the power of genomic technologies will allow surgeons to lead a new era of precision surgery. This will allow for personalized therapies, optimized outcomes, and proactive management of the underlying genetic factors impacting disease pathology. The amalgamation of genetics and surgery holds great promise for enhancing patient care and influencing surgical practice in the future as genetic research and technology develop.

4 | Bioengineering Innovations in Tissue Reconstruction

Bioengineering breakthroughs are altering tissue reconstruction by introducing new methods for restoring injured or destroyed tissues [63]. 3/4D printing, tissue engineering, and biomaterials are revolutionizing implant and tissue creation, allowing for more customized solutions with improved biocompatibility and regenerative potential [64, 65]. From difficult organ transplants to face restoration, bioengineering ushers in a new era of accuracy in surgical procedures. These breakthroughs combine biology, engineering, and materials science principles to create biomimetic scaffolds, cell-based therapeutics, and tissue-engineering approaches.

4.1 | Biomimetic Scaffolds

Bioengineers design scaffolds that offer structural support and biochemical signals to facilitate cell attachment, proliferation, and differentiation for tissue and organ repair and reconstruction following trauma or surgery. These scaffolds mimic the native extracellular matrix and can be fabricated into diverse shapes and architectures to meet specific tissue reconstruction requirements. For instance, Chen et al. [66] assessed the efficiency of a biphasic scaffold loaded with autologous cartilage in patients with focal osteochondral lesions. Results indicated that the biphasic scaffold exhibited better clinical outcomes and cartilage refill than marrow stimulation. This advancement represents a significant breakthrough for future surgeries, particularly in cases of extensive tissue damage, creating a new era in the preservation of organ structure and function.

4.2 | 3/4D Bioprinting

Personalized tissue reconstruction and organ transplantation are made possible by 3/4D bio printing technology, which allows bioengineers to create scaffolds and tissue models that are customized to each patient's anatomy [67, 68]. In an RCT, Kesavan et al. [69] developed 3D bio printing-based extracellular matrix to manage diabetic foot ulcers. Compared with conventional treatment, patients who received a 3D bio printing-based extracellular matrix showed superior diabetic wound healing. 3D bio printing is increasingly being applied in clinical settings with promising outcomes. Its patient-specific design and fabrication approach offers superior suitability compared with conventional mass-produced materials.

4.3 | Cell-Based Therapies

Stem cells, including mesenchymal stem cells, induced pluripotent stem cells, and adult tissue-specific stem cells, hold immense potential for tissue regeneration [70]. Bioengineers harness the regenerative capacity of stem cells by seeding them onto scaffolds or incorporating them into injectable hydrogels, thereby promoting tissue repair, angiogenesis, and remodeling in vivo. Stem cell spheroids with protein/polyphenol self-assembling armor could induce immunoprotection and immunoregulation to improve myocardial infarction therapies [71]. Zhu et al. [72] developed

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

a microrobot that exhibited natural red blood cell-mimetic circulation behavior due to its nearly identical surface properties, yet remained magnetically guidable for targeted accumulation at pathological sites, where subsequent laser-triggered ablation simultaneously released therapeutic payloads and generated localized heat to enhance vascular drug extravasation.

4.4 | Decellularization and Recellularization

The extracellular matrix architecture and metabolic signals are preserved in donor tissues while cellular components are removed using decellularization procedures. Through the process of recellularization, bioengineers replenish these decellularized scaffolds with patient-derived cells to produce tissue-engineered constructions that, whether transplanted or studied in vitro, closely resemble native tissues in terms of both biology and mechanics. For example, Coppi et al. [71] successfully constructed a model of the lung by removing rat lung cells and implanting human lung cells, which can be utilized for various experiments. This strategy establishes a robust foundation for organ cultivation and injury repair while effectively preventing immune rejection through the use of patient-derived cells.

4.5 | Gene Therapy

Utilizing gene therapy techniques, therapeutic genes or growth factors are directly delivered to target tissues in order to influence cellular responses, encourage tissue regeneration, and quicken the healing of wounds. Of these, immunotherapy is an outstanding therapy of gene therapy and effectively controls cancer progression [73]. Among these, gene delivery vectors, such as viral vectors or nanoparticles, can improve the effectiveness of gene transfer and regulate the levels of gene expression inside the intended tissue microenvironment.

4.6 | Organ-on-a-Chip Technology

Organ-on-a-chip systems allow scientists to simulate in vitro tissue interactions, medication reactions, and disease processes by simulating human organ physiological activities inside microfluidic devices [74]. To investigate tissue reconstruction and therapeutic interventions under physiologically realistic settings, bioengineers include perfusable vascular networks, tissue-specific cells, and biomimetic microenvironments into organ-on-a-chip devices [75]. Organ-on-a-chip systems provide more physiologically relevant experimental conditions than animal models (such as mice), yielding results that better approximate human responses. These systems represent a promising tool for future drug development, efficacy and safety testing, while substantially reducing reliance on animal models.

4.7 | Bioactive Materials and Drug Delivery Systems

Bioactive materials offer spatiotemporal control over the delivery of bioactive chemicals to target tissues [76, 77]. In tissue reconstruction applications, bioengineers create drug delivery systems with stimuli-responsive, localized, and sustained release capabilities to maximize therapeutic efficacy and reduce off-target consequences. For instance, human red blood cell-derived vesicles could transport lysosomal-targeted doxorubicin to overcome chemoresistance cancers [78]. Examples of these materials include hydrogels, nanoparticles, and growth factor-releasing scaffolds. These advanced materials and systems facilitate targeted drug delivery to specific sites or even individual cells, significantly reducing adverse effects while enhancing therapeutic efficacy.

4.8 | Immunomodulation Strategies

Tissue regeneration and repair depend heavily on immune responses. In order to control the immunological milieu, reduce inflammation, encourage tissue regeneration, and reduce fibrosis and scarring after surgery or injury, bioengineers create immunomodulatory biomaterials and cell treatments. In cancer, many immunomodulation-based treatments have been applied in clinical practice, such as immune checkpoint inhibitors [79], CAR immune cell therapy [80], and cancer vaccine [81]. These immunomodulatory therapies can be administered either alone or in combination with other treatments [6]. They help establish an immunosuppressive tumor microenvironment to eliminate residual cancer cells and prevent postoperative recurrence, thereby providing effective adjuvant therapy. Additionally, immunomodulators play a significant role in wound healing and tissue regeneration.

Researchers and medical professionals are advancing tissue reconstruction by incorporating these bioengineering advancements, providing promising solutions for replacing and repairing damaged tissues in a variety of clinical scenarios, such as organ transplantation, wound healing, trauma reconstruction, and regenerative medicine therapies.

5 | Rehabilitation Techniques Redefining Surgical Recovery

Rehabilitation has emerged as an essential component of the surgical framework, optimizing patient outcomes, promoting functional restoration, and improving quality of life after surgical procedures. These procedures take a multidisciplinary approach, combining physical therapy, occupational therapy, assistive technologies, and psychosocial support to meet the different requirements of patients following surgery [82–84]. Advanced rehabilitation approaches use VI, wearable gadgets, and robotic-assisted therapies to speed up recovery, improve functional outcomes, and increase patient happiness [85–87].

5.1 | Early Mobilization and Physical Therapy

Early mobilization and physical therapy programs aim to reduce postoperative consequences such as muscular weakness, joint stiffness, and respiratory problems by starting rehabilitation activities and ambulation as soon as clinically possible. The ERAS is a comprehensive medical management model aimed at optimizing patient care before, during, and after surgery.

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Its goal is to minimize surgical trauma and stress responses, shorten recovery times, reduce complication rates, and enhance the quality of surgical recovery [88–90]. Early Mobilization is an essential component of postoperative rehabilitation, emphasizing the importance of patients initiating activity soon after surgery [88]. Early mobilization helps prevent complications such as pneumonia, deep vein thrombosis, and muscle atrophy. It also aids in restoring muscle function in patients, enhancing circulatory and respiratory system functionality, and promoting recovery [91–93]. This may involve activities such as standing, walking, and performing simple limb exercises [94]. Physical therapists provide customized exercise programs based on the patient's surgical procedure, functional status, and rehabilitation goals in order to enhance strength, flexibility, and mobility during the healing period. The combination of early mobilization and physical therapy establishes a solid foundation for postoperative recovery, serving as a crucial cornerstone for ensuring surgical efficacy.

5.2 | Prehabilitation Programs

Prehabilitation programs include focused exercise interventions, dietary counseling, and psychosocial support that are offered prior to surgery to ensure patients' physical and psychological preparedness for the procedure [95, 96]. Prehabilitation programs minimize the incidence of postoperative problems by enhancing preoperative fitness, muscle strength, and overall health. They also speed up recovery and improve surgical outcomes [97–99]. Despite the long-standing practice of preoperative smoking cessation, awareness of prehabilitation programs remains limited in clinical preoperative preparation. This necessitates greater surgical team engagement and collaboration with rehabilitation specialists.

5.3 | Occupational Therapy

Occupational therapists help patients regain independence in activities of daily life after surgery, such as bathing, dressing, cooking, and driving [100–102]. For example, mental health occupational therapy is a specialized branch of occupational therapy that addresses the unique needs of individuals experiencing mental health difficulties [103]. Occupational therapists in this field work closely with patients to assess their cognitive, emotional, social, and functional abilities, taking into account their personal goals and environmental factors [104]. Through collaborative goal-setting, therapists help patients engage in activities that are personally meaningful and contribute to their overall well-being [104, 105]. Occupational therapy therapies aim to improve fine motor skills, cognitive function, and adaptive methods to help patients adjust to life at home and in the community when they leave the hospital.

5.4 | Supportive Technologies and Flexible Devices

Supportive technologies, such as prosthetics, orthotics, mobility aids, and adaptive equipment, are crucial in helping patients recover functionally and participate in daily activities [106–108]. Rehabilitation professionals evaluate patients' assistive technology requirements and offer personalized recommendations, training, and changes to maximize device utilization and independence during the rehabilitation process.

5.5 | Telemedicine and Virtual Rehabilitation

Telemedicine services and virtual rehabilitation platforms allow for the remote provision of rehabilitation therapies, patient progress tracking, and continuous rehabilitation specialist assistance [109, 110]. Tele-rehabilitation sessions enhance accessibility and continuity of care during the postoperative recovery period by enabling patients to participate in virtual therapy sessions, access personalized exercise programs, and receive real-time feedback from the comfort of their homes [111, 112]. For example, Li et al. [113]. conducted a feasibility RCT to examine the effects of a home-based occupational therapy telerehabilitation program via smartphones on functional and motor performance, as well as fall efficacy, in older adults undergoing day hospital rehabilitation after hip fracture surgery in Hong Kong. Results revealed significant improvements in fall efficacy and instrumental activities of daily living performance in the experimental group compared with the comparison group, indicating the potential efficacy of telerehabilitation as an alternative home program for occupational therapy practice with this population. Telemedicine services and virtual rehabilitation platforms enable real-time guidance, supervision, and correction of rehabilitation training for patients. Their convenience facilitates wider adoption among patients with mild-to-moderate functional impairments, eliminating the need for hospital-based rehabilitation in selected patients while significantly reducing patients' financial burden.

5.6 | Pain Management Strategies

Pain management techniques include pharmacological interventions, regional anesthesia techniques, and non-pharmacological modalities like acupuncture [114], mindfulness-based therapies [115], and transcutaneous electrical nerve stimulation [116]. Comprehensive pain management techniques reduce postoperative pain, promote early mobilization, and improve patients' general comfort and well-being throughout the healing process.

5.7 | Psychosocial Support and Counseling

Patients' emotional, social, and psychological needs are met by psychosocial support services, which include peer support groups, stress management, and counselling, all during the surgical recovery process. Psychosocial therapies support emotional well-being and holistic healing by encouraging resilience, coping mechanisms, and adaptive adjustment to life changes after surgery [117–119]. The concept of psychosomatic medicine has been widely established. By promoting psychological well-being, it facilitates physical recovery and supports patients' social reintegration and return to normal daily functioning.

5.8 | Patient Education and Empowerment

Patient education initiatives enable patients to take an active role in their own healing, comprehend the nature of their surgery,

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

and follow recommended rehabilitation procedures [120–122]. Patient education programs facilitate autonomy, self-efficacy, and involvement in rehabilitation activities by offering comprehensive knowledge about postoperative care, self-management tools, and goal setting. This, in turn, improves surgical recovery results.

6 | Looking Forward

This work highlights the transformative impact of emerging technologies on surgical advancement. These innovations enable comprehensive perioperative management spanning preoperative assessment, surgical preparation, intraoperative assistance, and postoperative care. AI serves as the central integrator, synergizing genetic technology, bioengineering, and rehabilitation to revolutionize conventional surgical practice. Modern surgery has evolved from a focus on preoperative preparation and operative techniques to a systematic continuum extending from outpatient evaluation to complete postoperative recovery. This paradigm shift presents new challenges and demands for contemporary surgical practitioners. Although the combination of AI, genetic technology, bioengineering, and rehabilitation has great potential, there are significant ethical, legal, and societal issues that need to be addressed. Priorities include eliminating inequities in healthcare delivery, protecting patient autonomy and privacy, and ensuring equal access to technological breakthroughs. Moreover, negotiating the moral, legal, and societal challenges of surgical innovation requires encouraging interdisciplinary cooperation and holding open discussions with stakeholders.

6.1 | Training Surgeons for the Future

An entirely new approach to surgical education and training is required due to the changing nature of surgery [123]. Three key components of contemporary surgical education—simulation-based learning, AR platforms, and interdisciplinary collaboration—empower surgeons with the necessary abilities to handle the complexity of next-generation surgical technologies. Surgical training programs prepare the next generation of surgeons to meet the opportunities and challenges of a constantly changing healthcare landscape by promoting a culture of innovation and lifelong learning. In an education study, AI could pass a medical exam [124]. Furthermore, surgical students improved ergonomics after being trained by an AI-assisted ergonomics analysis app which could provide immediate feedback to surgical trainees [125]. For instance, an AI-assisted surgical coaching program could significantly enhance operative performance and safety for novice surgeons performing laparoscopic cholecystectomy by providing comprehensive perioperative support, including preoperative preparation, intraoperative video analysis, and postoperative evaluation [126]. For experienced surgeons, AI can analyze their surgical procedures to identify areas for technique refinement and improvement, providing valuable feedback for skill enhancement [127]. However, additionally, AI could conclude medical research [37]. This function could help surgeons learn knowledge from other fields and quickly understand the synergy of interdisciplinarity.

6.2 | Reforming Medical Education

Medical education needs to be completely revamped in order to guarantee that technological improvements are seamlessly incorporated into surgical practice. Interdisciplinary training modules covering ethics, legislation, and social ramifications should be incorporated into curricula to develop surgeons who are well-rounded and able to navigate the ethical, legal, and societal difficulties that come with evolving technologies. Medical education builds a future in which surgical procedures are not only technically sound but also morally and socially just by encouraging a culture of creativity, inclusion, and ethical responsibility [128]. An important aspect is to learn to doubt the correctness of answers. Due to the probability of errors in the answers provided by AI, such errors may harm patients [129]. Therefore, medical education must emphasize cultivating students' spirit of questioning things.

Furthermore, patient education regarding treatment cycle modifications should be implemented through a multi-phase approach: (1) out-of-hospital education via professionally reviewed educational materials; (2) outpatient consultations (in-person or telemedicine) to explain new treatment protocols; and (3) hospitalization-phase education using AI-generated personalized treatment plans. These plans, visualized through modeling technologies (e.g., 3D reconstruction, VR simulations) of the patient's own diagnostic data, enhance comprehension of future treatment pathways while improving physician-patient communication efficiency.

6.3 | Challenges and Ethical Considerations

The adoption of genetic technologies, bioengineering and AI in surgery presents several challenges and ethical concerns [130]. AI systems are only as good as the data they are trained on when it comes to the issues of the AI. Surgeons and patients may find it challenging to comprehend the decision-making processes of AI systems due to their frequent opacity. Relying too much on AI can diminish the surgeon's professional autonomy and judgment. The integration of AI systems like DeepSeek into hospital settings raises concerns about potential limitations on physicians' independent thinking. Moreover, AI may generate incorrect answers, potentially leading to erroneous treatments [129]. Therefore, we argue that regardless of AI's advancement, physicians must maintain independent decision-making capabilities. To mitigate AI's impact on clinical judgment, several measures can be implemented: (1) requiring AI systems to display detailed reasoning processes, enabling physicians to evaluate the logic and reliability of conclusions while maintaining critical thinking skills; (2) mandating comprehensive citation of sources for all AI-generated answers to ensure traceability; (3) clearly labeling AI outputs as reference materials rather than definitive answers; and (4) explicitly reminding surgeons that they remain partly responsible for treatment decisions, thereby reinforcing their critical engagement with all diagnostic and therapeutic options. In terms of ethic or legal issues, it may not always be apparent who is ultimately accountable for judgements made using AI, particularly when those decisions have unfavorable consequences. Who is to blame—hospitals, developers, or surgeons [131]? Furthermore, a lot of data is needed for AI systems, and a

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

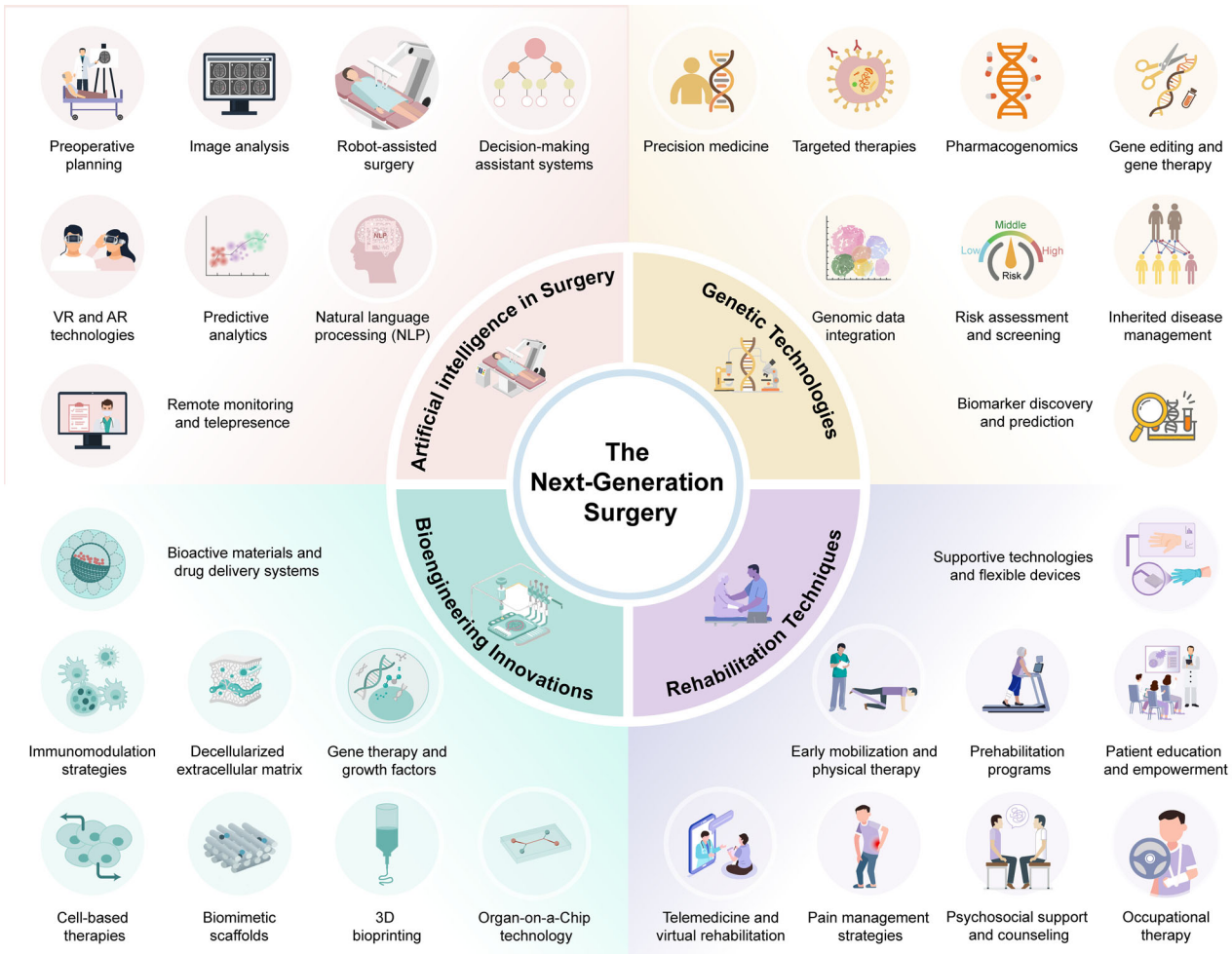


FIGURE 1 | The summary of this article.

lot of that data may contain sensitive patient data, which presents serious privacy issues.

The complexity of the mechanics and ramifications of genetic interventions presents a challenge for genetic technology, one that can be challenging for patients and doctors to completely comprehend. Because genetic connections within the human body are complex, genetic alterations may have unanticipated consequences [132]. Consequently, ethical issues include the following [30, 133]: there is a chance that genetic information will be used to discriminate against people in the insurance market, the workplace, or other spheres of life; the possibility of selecting or modifying genetic traits for purposes other than therapy raises ethical questions about eugenics and the commercialization of human genetic modification; and obtaining informed consent is made more difficult by the complex information that patients must understand, including potential risks and benefits. Regarding bioengineering, the difficulties lie in developing tools and materials that blend in with human tissues in a safe and efficient manner while avoiding negative reactions, as well as making sure that organs and tissues that have been bioengineered will continue to be safe and functioning in the long run [134, 135]. The high cost of bioengineering technologies may cause access disparities that favor wealthy patients or nations in the interim. Therefore, there are ethical concerns regarding the moral ramifications of creating and modifying life forms, including the possibility of "playing God" [136]. Additionally, the production and disposal of bioengineered materials may have unanticipated environmental effects.

All technologies have general ethical considerations, such as making advanced technologies available to all socioeconomic groups to prevent the spread of health disparities; making sure patients are informed about the risks and benefits of new technologies and have the ability to make decisions about their use; creating comprehensive regulations that keep up with technological advancements to ensure patient safety and ethical compliance; and taking into account the possibility of these technologies being misused in non-medical contexts, which could have serious ethical ramifications [137, 138]. Overall, a coordinated effort involving healthcare practitioners, researchers, policymakers, ethicists, patient advocates, and industry stakeholders is necessary to address these issues and ethical concerns. We can harness the potential of genetic technology and AI to revolutionize surgical care while protecting patient rights, autonomy, and dignity by encouraging discourse, promoting transparency, and preserving ethical norms. Figure 1 exhibited the above perspectives.

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

7 | Conclusion

In summary, the integration of cutting-edge technologies such as AI, genetic technologies, bioengineering, and rehabilitation portends a revolution in surgical operations. Through leveraging innovation and tackling related obstacles, the surgical community may lead the path toward a future where surgical treatment is not just cutting edge in terms of technology but also individualized, compassionate, and all-encompassing. By working together and exercising ethical stewardship, we can fully utilize next-generation surgical technologies and bring in a new era of excellence, compassion, and precision in surgical practice.

Author Contributions

DCF, DXL, JW and ZPW proposed the project, conducted data analysis, interpreted the data, and wrote the manuscript; all authors conducted data analysis, interpreted the data; DCF, KHY, SH, ZHL and WCC supervised the project, and interpreted the data. All authors reviewed and edited the manuscript.

Acknowledgments

We appreciated the supports of Chinese Scholarship Council (Grant Number. 202206240086). We also appreciated the Figdraw (www.figdraw.com) and Chengdu Basebiotech Co,Ltd for their assistance in drawing and data process. The authors utilized AI-assisted editing tool (ChatGPT-4 and DeepSeek) solely for language refinement purposes, including grammar checking, sentence structure optimization, and vocabulary enhancement. All conceptual development, technical content, and critical analysis remain entirely human-generated. The authors take full responsibility for the accuracy of information and academic integrity of this work.

Funding

The authors have nothing to report.

Ethical Statement

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

References

1. L. Wyld, R. A. Audisio, and G. J. Poston, "The Evolution of Cancer Surgery and Future Perspectives," *Nature reviews Clinical Oncology* 12, no. 2 (2015): 115–124, https://doi.org/10.1038/nrclinonc.2014.191.

2. S. G. Kim, S. E. Lee, B. W. Eom, H. M. Yoon, Y. W. Kim, and K. W. Ryu, "Gastric Cancer Surgery in South Korea: Past, Present, and Future," *Chinese Journal of Cancer Research = Chung-Kuo Yen Cheng Yen Chiu* 35, no. 6 (2023): 627–635.PMID: 38204450.

3. A. M. Lacy, R. Bravo, A. M. Otero-Piñeiro, et al., "5G-Assisted Telementored Surgery," *British Journal of Surgery* 106, no. 12 (2019): 1576–1579, https://doi.org/10.1002/bjs.11364.

4. H. Ashrafian, O. Clancy, V. Grover, and A. Darzi, "The Evolution of Robotic Surgery: Surgical and Anaesthetic Aspects," *British Journal of Anaesthesia* 119, no. suppl_1 (2017): i72–i84, https://doi.org/10.1093/bja/aex383.

5. M. M. Chowdhury, H. Dagash, and A. Pierro, "A Systematic Review of the Impact of Volume of Surgery and Specialization on Patient Outcome," *British Journal of Surgery* 94, no. 2 (2007): 145–161, https://doi.org/10.1002/bjs.5714.

6. D. Li, J. Wang, X. Li, et al., "Interactions Between Radiotherapy Resistance Mechanisms and the Tumor Microenvironment," *Critical Reviews in Oncology/Hematology* 210 (2025): 104705, https://doi.org/10.1016/j.critrevonc.2025.104705.

7. C. Armengol-García, V. Blandin-Alvarez, C. López-García, and E. Flores-Villalba, "Combined General and Neuraxial Anesthesia Versus General Anesthesia Alone for Laparoscopic Cholecystectomy: A Meta-Analysis of Pain Control and Hemodynamic Stability," *Updates in Surgery* (2025), https://doi.org/10.1007/s13304-025-02217-x.

8. C. L. Mullens, R. A. Collins, N. Kunnath, J. C. Probst, and A. M. Ibrahim, "Trends in Travel Time to Obtain Surgical Care for Rural Patients," *Jama* 333, no. 16 (2025): 1453–1455, https://doi.org/10.1001/jama.2025.0447.

9. C. H. Evans and K. D. Schenarts, "Evolving Educational Techniques in Surgical Training," *Surgical Clinics of North America* 96, no. 1 (2016): 71–88, https://doi.org/10.1016/j.suc.2015.09.005.

10. Y. Lee, J. Khamar, Y. Samarasinghe, T. McKechnie, B. Petrisor, and I. Yang, "The Surgical Education Checklist: A Novel Tool to Improve the Use of Entrustable Professional Activities in Operative Training in Competence by Design," *Journal of Surgical Education* 82, no. 5 (2025): 103470, https://doi.org/10.1016/j.jsurg.2025.103470.

11. N. I. Ibrahim, C. Settoon, K. Kazahaya, and E. Z. Stucken, "Complications of Surgery," *Otolaryngologic Clinics of North America* 58, no. 1 (2025): 165–175, https://doi.org/10.1016/j.otc.2024.08.004.

12. R. Jhunjhunwala and S. Venkatapuram, "How Should We Prioritise Global Surgery? A Capabilities Approach Argument for the Place of Surgery Within Every Health System," *BMJ Global Health* 8, no. 11 (2023): e013100, https://doi.org/10.1136/bmjgh-2023-013100.

13. R. Yang, J. Zhang, F. Zhan, et al., "Artificial Intelligence Efficiently Predicts Gastric Lesions, Helicobacter Pylori Infection and Lymph Node Metastasis Upon Endoscopic Images," *Chinese Journal of Cancer Research = Chung-Kuo Yen Cheng Yen Chiu* 36, no. 5 (2024): 489–502, https://doi.org/10.21147/j.issn.1000-9604.2024.05.03.

14. V. Leivaditis, A. A. Maniatopoulos, H. Lausberg, et al., "Artificial Intelligence in Thoracic Surgery: A Review Bridging Innovation and Clinical Practice for the Next Generation of Surgical Care," *Journal of Clinical Medicine* 14, no. 8 (2025): 2729, https://doi.org/10.3390/jcm14082729.

15. Q. X. Yu, D. C. Feng, R. C. Wu, and D. X. Li, "Auxiliary Use of ChatGPT in Surgical Diagnosis and Treatment—Correspondence," *International Journal of Surgery* 110, no. 1 (2024): 617–618, https://doi.org/10.1097/JS9.0000000000000818.

16. Q. X. Yu, R. C. Wu, D. C. Feng, and D. X. Li, "Re: ChatGPT Encounters Multiple Opportunities and Challenges in Neurosurgery," *International Journal of Surgery* 109, no. 12 (2023): 4393–4394, https://doi.org/10.1097/JS9.0000000000000749.

17. S. Y. Liu, S. Y. Xu, L. Yin, et al., "Management of Regional Citrate Anticoagulation for Continuous Renal Replacement Therapy: Guideline Recommendations From Chinese Emergency Medical Doctor Consensus," *Military Medical Research* 10, no. 1 (2023): 23.

18. A. S. Millarch, F. Folke, S. S. Rudolph, H. M. Kaafarani, and M. Sillesen, "Prehospital Triage of Trauma Patients: Predicting Major Surgery Using Artificial Intelligence as Decision Support," *British Journal of Surgery* 112, no. 4 (2025): znaf058, https://doi.org/10.1093/bjs/znaf058.

19. K. C. Maita, F. R. Avila, R. A. Torres-Guzman, et al., "The Usefulness of Artificial Intelligence in Breast Reconstruction: A Systematic Review,"

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Breast Cancer (Tokyo, Japan) 31 (2024): 562–571, https://doi.org/10.1007/s12282-024-01582-6.

20. K. Cheng, Z. Li, Q. Guo, Z. Sun, H. Wu, and C. Li, "Emergency Surgery in the Era of Artificial Intelligence: ChatGPT Could be the Doctor's Right-Hand Man," *International Journal of Surgery* 109, no. 6 (2023): 1816–1818, https://doi.org/10.1097/JS9.0000000000000410.

21. L. T. Zhao, Z. Y. Liu, W. F. Xie, et al., "What Benefit Can be Obtained From Magnetic Resonance Imaging Diagnosis With Artificial Intelligence in Prostate Cancer Compared With Clinical Assessments?," *Military Medical Research* 10, no. 1 (2023): 29.

22. C. You, Y. Shen, S. Sun, et al., "Artificial Intelligence in Breast Imaging: Current Situation and Clinical Challenges," *Exploration* 3, no. 5 (2023): 20230007, https://doi.org/10.1002/EXP.20230007.

23. Y. Ding, J. Zhang, W. Zhuang, et al., "Improving the Efficiency of Identifying Malignant Pulmonary Nodules Before Surgery Via a Combination of Artificial Intelligence CT Image Recognition and Serum Autoantibodies," *European Radiology* 33, no. 5 (2023): 3092–3102, https://doi.org/10.1007/s00330-022-09317-x.

24. H. Mei, H. Chen, Q. Zheng, et al., "Foundation Model and Radiomics-Based Quantitative Characterization of Perirenal Fat in Renal Cell Carcinoma Surgery," *Academic Radiology* 32, no. 7 (2025): 4041–4049, https://doi.org/10.1016/j.acra.2025.03.002.

25. C. Hardacre, T. Hibbs, M. Fok, et al., "Predicting Surgical Difficulty in Rectal Cancer Surgery: A Systematic Review of Artificial Intelligence Models Applied to Pre-Operative MRI," *Cancers* 17, no. 5 (2025): 812, https://doi.org/10.3390/cancers17050812.

26. M. Cè, M. Cellina, T. Ueanukul, et al., "Multimodal Imaging of Osteosarcoma: From First Diagnosis to Radiomics," *Cancers* 17, no. 4 (2025): 599.

27. K. Y. Ho, "Beyond Images: Emerging Role of Raman Spectroscopy-Based Artificial Intelligence in Diagnosis of Gastric Neoplasia," *Chinese Journal of Cancer Research = Chung-Kuo Yen Cheng Yen Chiu* 34, no. 5 (2022): 539–542, https://doi.org/10.21147/j.issn.1000-9604.2022.05.13.

28. S. W. Li, L. H. Zhang, Y. Cai, et al., "Deep Learning Assists Detection of Esophageal Cancer and Precursor Lesions in a Prospective, Randomized Controlled Study," *Science Translational Medicine* 16, no. 743 (2024): eadk5395, https://doi.org/10.1126/scitranslmed.adk5395.

29. X. L. Yuan, W. Liu, Y. X. Lin, et al., "Effect of an Artificial Intelligence-Assisted System on Endoscopic Diagnosis of Superficial Oesophageal Squamous Cell Carcinoma and Precancerous Lesions: A Multicentre, Tandem, Double-Blind, Randomised Controlled Trial," *Lancet Gastroenterology and Hepatology* 9, no. 1 (2024): 34–44, https://doi.org/10.1016/S2468-1253(23)00276-5.

30. C. Palme, F. S. Hafner, L. Hafner, T. P. Peifer, A. L. Huber, and B. Steger, "Artificial Intelligence (AI) Reveals Ethnic Disparities in Cataract Detection and Treatment," *Ophthalmology and Therapy* 13, no. 6 (2024): 1683–1692, https://doi.org/10.1007/s40123-024-00945-8.

31. R. Miyamoto, M. Shiihara, M. Shimoda, and S. Suzuki, "Laparoscopic Distal Pancreatectomy Using Three-Dimensional Computer Graphics for Surgical Navigation with a Deep Learning Algorithm: A Case Report," *Cureus* 16, no. 3 (2024): e55907.PMID: 38601417.

32. H. Chen, L. Gou, Z. Fang, et al., "Artificial Intelligence Assisted Real-Time Recognition of Intra-Abdominal Metastasis During Laparoscopic Gastric Cancer Surgery," *npj Digital Medicine* 8, no. 1 (2025): 9, https://doi.org/10.1038/s41746-024-01372-6.

33. R. Campi, F. Sessa, A. Rivetti, et al., "Case Report: Optimizing Pre- and Intraoperative Planning with Hyperaccuracy Three-Dimensional Virtual Models for a Challenging Case of Robotic Partial Nephrectomy for Two Complex Renal Masses in a Horseshoe Kidney," *Frontiers in surgery* 8 (2021): 665328, https://doi.org/10.3389/fsurg.2021.665328.

34. S. Yao, P. Shen, F. Dai, et al., "Thyroid Cancer Central Lymph Node Metastasis Risk Stratification Based on Homogeneous Positioning Deep Learning," *Research* 7 (2024): 0432.

35. Z. Liu, Y. Huang, H. Li, et al., "A Generalized Deep Learning Model for Heart Failure Diagnosis Using Dynamic and Static Ultrasound," *Journal of Translational Internal Medicine* 11, no. 2 (2023): 138–144, https://doi.org/10.2478/jtim-2023-0088.

36. P. Patel, S. Harmon, and R. Iseman, "Artificial Intelligence-Based PTEN Loss Assessment as an Early Predictor of Prostate Cancer Metastasis After Surgery: A Multicenter Retrospective Study," *Modern pathology: An official journal of the United States and Canadian Academy of Pathology, Inc* 36, no. 10 (2023): 100241, https://doi.org/10.1016/j.modpat.2023.100241.

37. J. M. Perkel and R. Van Noorden, "tl;dr: This AI Sums up Research Papers in a Sentence," *Nature* (2020), https://doi.org/10.1038/d41586-020-03277-2.

38. D. Feng, X. Shi, J. Wang, et al., "Telemedicine-Medical "Snack Community"-PHS Ecosystem: Insights Into the Double-Edged Sword Role of Telemedicine in Clinical Practice and Medical Education During the COVID-19 Pandemic and Beyond," *Exploration* 4, no. 4 (2024): 20230111, https://doi.org/10.1002/EXP.20230111.

39. W. Tian, M. Fan, C. Zeng, Y. Liu, D. He, and Q. Zhang, "Telerobotic Spinal Surgery Based on 5G Network: The First 12 Cases," *Neurospine* 17, no. 1 (2020): 114–120, https://doi.org/10.14245/ns.1938454.227.

40. D. Feng, D. Li, R. Wu, and P. Han, "Scientific Advancements in Drug Development and Trials for Urothelial Carcinoma: Insights from the 2023 ASCO-GU Cancers Symposium," *Aging and Disease* 14, no. 6 (2023): 1953, https://doi.org/10.14336/AD.2023.0502.

41. D. C. Feng, W. Z. Zhu, J. Wang, et al., "The Implications of Single-Cell RNA-seq Analysis in Prostate Cancer: Unraveling Tumor Heterogeneity, Therapeutic Implications and Pathways towards Personalized Therapy," *Military Medical Research* 11, no. 1 (2024): 21.

42. D. X. Li, D. C. Feng, X. Shi, R. C. Wu, K. Chen, and P. Han, "Identification of Endothelial-Related Molecular Subtypes for Bladder Cancer Patients," *Frontiers in Oncology* 13 (2023): 1101055, https://doi.org/10.3389/fonc.2023.1101055.

43. S. Ribero, P. Quaglino, and G. Roccuzzo, "Collaborative Efforts in Studying Mediterranean Melanoma Families: A Step towards Precision Medicine," *Journal of the European Academy of Dermatology and Venereology* 37, no. 12 (2023): 2405–2406, https://doi.org/10.1111/jdv.19529.

44. L. A. Nurla, E. Gheorghe, M. Aşchie, G. C. Cozaru, C. I. Orăşanu, and M. Boşoteanu, "P16-CD8-Ki67 Triple Algorithm for Prediction of CDKN2A Mutations in Patients With Multiple Primary and Familial Melanoma," *Diagnostics* 14, no. 8 (2024): 813, https://doi.org/10.3390/diagnostics14080813.

45. X. Shao, N. Xie, Z. Chen, et al., "Inetetamab for Injection in Combination With Vinorelbine Weekly or Every Three Weeks in HER2-Positive Metastatic Breast Cancer: A Multicenter, Randomized, Phase II Clinical Trial," *Journal of Translational Internal Medicine* 12, no. 5 (2024): 466–477, https://doi.org/10.1515/jtim-2024-0022.

46. L. Mao, M. Yang, X. Fan, et al., "PD-1/L1 Inhibitors Can Improve But Not Replace Chemotherapy for Advanced Urothelial Carcinoma: A Systematic Review and Network Meta-Analysis," *Cancer Innovation* 2, no. 3 (2023): 191–202, https://doi.org/10.1002/cai2.75.

47. A. Antoniou, P. D. Pharoah, S. Narod, et al., "Average Risks of Breast and Ovarian Cancer Associated With BRCA1 or BRCA2 Mutations Detected in Case Series Unselected for family History: A Combined Analysis of 22 Studies," *American Journal of Human Genetics* 72, no. 5 (2003): 1117–1130, https://doi.org/10.1086/375033.

48. S. Vos, P. J. van Diest, and C. B. Moelans, "A Systematic Review on the Frequency of BRCA Promoter Methylation in Breast and Ovarian Carcinomas of BRCA Germline Mutation Carriers: Mutually Exclusive, or Not?," *Critical Reviews in Oncology/Hematology* 127 (2018): 29–41, https://doi.org/10.1016/j.critrevonc.2018.05.008.

49. G. Szentmartoni, D. Mühl, R. Csanda, A. M. Szasz, Z. Herold, and M. Dank, "Predictive Value and Therapeutic Significance of Somatic BRCA

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Mutation in Solid Tumors," *Biomedicines* 12, no. 3 (2024): 593, https://doi.org/10.3390/biomedicines12030593.

50. L. Asta, G. A. D'Angelo, D. Marinelli, and U. Benedetto, "Genetic Basis, New Diagnostic Approaches, and Updated Therapeutic Strategies of the Syndromic Aortic Diseases: Marfan, Loeys–Dietz, and Vascular Ehlers–Danlos Syndrome," *International Journal of Environmental Research and Public Health* 20, no. 16 (2023): 6615, https://doi.org/10.3390/ijerph20166615.

51. D. M. Milewicz, A. C. Braverman, J. De Backer, et al., "Marfan Syndrome," *Nature reviews Disease primers* 7, no. 1 (2021): 64, https://doi.org/10.1038/s41572-021-00298-7.

52. D. Li, Q. Yu, R. Wu, et al., "Chronobiology of the Tumor Microenvironment: Implications for Therapeutic Strategies and Circadian-Based Interventions," *Aging and Diseases* 16, no. 2 (2024): 645, https://doi.org/10.14336/AD.2024.0327.

53. J. A. Johnson, L. Gong, M. Whirl-Carrillo, et al., "Clinical Pharmacogenetics Implementation Consortium Guidelines for CYP2C9 and VKORC1 Genotypes and Warfarin Dosing," *Clinical Pharmacology and Therapeutics* 90, no. 4 (2011): 625–629, https://doi.org/10.1038/clpt.2011.185.

54. M. Takemura, K. Niki, Y. Okamoto, et al., "Comparison of the Effects of OPRM1 A118G Polymorphism Using Different Opioids: A Prospective Study," *Journal of Pain and Symptom Management* 67, no. 1 (2024): 39–49.e35, https://doi.org/10.1016/j.jpainsymman.2023.09.017.

55. M. Escorial, J. Muriel, L. Agulló, et al., "Clinical Prediction of Opioid Use Disorder in Chronic Pain Patients: A Cohort-Retrospective Study With a Pharmacogenetic Approach," *Minerva Anestesiologica* 90, no. 5 (2024): 386–396, https://doi.org/10.23736/S0375-9393.24.17864-9.

56. A. Jalil, M. M. Donate, and J. Mattei, "Exploring Resistance to Immune Checkpoint Inhibitors and Targeted Therapies in Melanoma," *Cancer Drug Resist* 7 (2024): 42.PMID: 39534873.

57. M. Pfeifer, J. S. Brammeld, S. Price, et al., "Genome-Wide CRISPR Screens Identify the YAP/TEAD Axis as a Driver of Persister Cells in EGFR Mutant Lung Cancer," *Communications Biology* 7, no. 1 (2024): 497, https://doi.org/10.1038/s42003-024-06190-w.

58. C. Z. Li and T. Y. Hu, "Nanotechnology Powered CRISPR-Cas Systems for Point of Care Diagnosis and Therapeutic," *Research (Washington, DC)* 2022 (2022): 9810237.

59. D. Henn, D. Zhao, D. Sivaraj, et al., "14. CRISPR/Cas9 Edited Dendritic Cells Accelerate Wound Healing by Targeting Wound Fibroblasts via Growth Factor Signaling," *Plastic and Reconstructive Surgery—Global Open* 12, no. S4 (2024): 10, https://doi.org/10.1097/01.GOX.0001015148.77646.c2.

60. D. M. Cohn, P. Gurugama, M. Magerl, et al., "CRISPR-Based Therapy for Hereditary Angioedema," *New England Journal of Medicine* 392, no. 5 (2025): 458–467, https://doi.org/10.1056/NEJMoa2405734.

61. D. X. Li, D. C. Feng, X. M. Wang, et al., "M7G-Related Molecular Subtypes Can Predict the Prognosis and Correlate With Immunotherapy and Chemotherapy Responses in Bladder Cancer Patients," *European Journal of Medical Research* 28, no. 1 (2023): 55, https://doi.org/10.1186/s40001-023-01012-x.

62. M. J. Duffy, "Biomarkers for Prostate Cancer: Prostate-Specific Antigen and Beyond," *Clinical Chemistry and Laboratory Medicine* 58, no. 3 (2020): 326–339, https://doi.org/10.1515/cclm-2019-0693.

63. Y. Wu, X. Ding, Y. Wang, and D. Ouyang, "Harnessing the Power of Machine Learning Into Tissue Engineering: Current Progress and Future Prospects," *Burns and Trauma* 12 (2024): tkae053, https://doi.org/10.1093/burnst/tkae053.

64. P. Pan, P. Zhang, S. Premachandran, et al., "High-Resolution Imaging and Morphological Phenotyping of *C. elegans* Through Stable Robotic Sample Rotation and Artificial Intelligence-Based 3-Dimensional Reconstruction," *Research (Wash D C)* 7 (2024): 0513.

65. Z. Meng, Y. Zhang, L. Yang, et al., "Application of Advanced Biosensors in Nervous System Diseases," *Interdisciplinary Medicine* 2, no. 4 (2024): e20240024, https://doi.org/10.1002/INMD.20240024.

66. C. P. Chen, P. W. Weng, K. T. Lee, L. Y. Chiang, W. J. Liao, and L. Shaw, "Biphasic Scaffold Loaded With Autologous Cartilage Yields Better Clinical Outcome and Magnetic Resonance Imaging Filling Compared With Marrow Stimulation for Focal Osteochondral Lesions in the Knee," *Arthroscopy* 41, no. 3 (2025): 688–699, https://doi.org/10.1016/j.arthro.2024.04.016.

67. S. Yan, F. Zhang, L. Luo, L. Wang, Y. Liu, and J. Leng, "Shape Memory Polymer Composites: 4D Printing, Smart Structures, and Applications," *Research (Washington, DC)* 6 (2023): 0234.

68. C. Jiang, Z. Jiang, S. Dai, et al., "The Application of 3D Printing Technology in Tumor Radiotherapy in the Era of Precision Medicine," *Applied Materials Today* 40 (2024): 102368, https://doi.org/10.1016/j.apmt.2024.102368.

69. R. Kesavan, C. Sheela Sasikumar, V. B. Narayanamurthy, A. Rajagopalan, and J. Kim, "Management of Diabetic Foot Ulcer With MA–ECM (Minimally Manipulated Autologous Extracellular Matrix) Using 3D Bioprinting Technology—An Innovative Approach," *The International Journal of Lower Extremity Wounds* 23, no. 1 (2024): 161–168, https://doi.org/10.1177/15347346211045625.

70. D. Kang, X. Wang, W. Chen, et al., "Epidermal Stem Cell-Derived Exosomes Improve Wound Healing by Promoting the Proliferation and Migration of Human Skin Fibroblasts," *Burns Trauma* 12 (2024): tkae047, https://doi.org/10.1093/burnst/tkae047.

71. C. An, F. Shao, C. Long, et al., "Local Delivery of Stem Cell Spheroids With Protein/Polyphenol Self-Assembling Armor to Improve Myocardial Infarction Treatment via Immunoprotection and Immunoregulation," *Biomaterials* 307 (2024): 122526, https://doi.org/10.1016/j.biomaterials.2024.122526.

72. Y. X. Zhu, H. R. Jia, Y. W. Jiang, et al., "A Red Blood Cell-Derived Bionic Microrobot Capable of Hierarchically Adapting to Five Critical Stages in Systemic Drug Delivery," *Exploration (Beijing)* 4, no. 2 (2024): 20230105, https://doi.org/10.1002/EXP.20230105.

73. D. Li, R. Wu, Q. Yu, et al., "Microbiota and Urinary Tumor Immunity: Mechanisms, Therapeutic Implications, and Future Perspectives," *Chinese Journal of Cancer Research = Chung-Kuo Yen Cheng Yen Chiu* 36, no. 6 (2024): 596–615, https://doi.org/10.21147/j.issn.1000-9604.2024.06.03.

74. Q. Yin, Z. Yang, S. W. Chong, et al., "Application of Microfluidic Technologies in Veterinary Science With a View Toward Development of Animal-on-a-Chip Models," *VIEW* 6, no. 1 (2025): 20240073, https://doi.org/10.1002/VIW.20240073.

75. M. Keuper-Navis, M. Walles, B. Poller, et al., "The Application of Organ-on-Chip Models for the Prediction of Human Pharmacokinetic Profiles During Drug Development," *Pharmacological Research* 195 (2023): 106853, https://doi.org/10.1016/j.phrs.2023.106853.

76. L. Zheng, R. Chang, B. Liang, et al., "Overcoming Drug Resistance Through Extracellular Vesicle-Based Drug Delivery System in Cancer Treatment," *Cancer Drug Resist* 7 (2024): 50.

77. S. Xiang, A. Khan, Q. Yao, and D. Wang, "Recent Advances in Bacterial Outer Membrane Vesicles: Effects on the Immune System, Mechanisms and Their Usage for Tumor Treatment," *Journal of Pharmaceutical Analysis* 14, no. 12 (2024): 101049, https://doi.org/10.1016/j.jpha.2024.101049.

78. C. P. Lin, S. H. Wu, T. Y. Lin, et al., "Lysosomal-Targeted Doxorubicin Delivery Using RBC-Derived Vesicles to Overcome Drug-Resistant Cancer Through Mitochondrial-Dependent Cell Death," *Pharmacological Research* 197 (2023): 106945, https://doi.org/10.1016/j.phrs.2023.106945.

79. D. Li, F. Shao, Q. Yu, et al., "The Complex Interplay of Tumor-infiltrating Cells in Driving Therapeutic Resistance Pathways," *Cell Communication and Signaling* 22, no. 1 (2024): 405, https://doi.org/10.1186/s12964-024-01776-7.

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

80. F. Guo, Y. Zhang, and J. Cui, "Manufacturing CAR-NK Against Tumors: Who is the Ideal Supplier?," *Chinese journal of cancer research = Chung-kuo yen cheng yen chiu* 36, no. 1 (2024): 1–16, https://doi.org/10.21147/j.issn.1000-9604.2024.01.01.

81. J. Xie, F. Ye, X. Deng, et al., "Circular RNA: A Promising New Star of Vaccine," *Journal of Translational Internal Medicine* 11, no. 4 (2023): 372–381, https://doi.org/10.2478/jtim-2023-0122.

82. A. Cheville, S. Smith, T. Barksdale, and A. Asher: Cancer Rehabilitation. In: *Braddom's Physical Medicine and Rehabilitation*. 2021: 568–593.e567.

83. N. L. Stout, C. M. Alfano, C. W. Belter, et al., "A Bibliometric Analysis of the Landscape of Cancer Rehabilitation Research (1992–2016)," *JNCI: Journal of the National Cancer Institute* 110, no. 8 (2018): 815–824, https://doi.org/10.1093/jnci/djy108.

84. D. Feng, J. Wang, Y. Xiao, et al., "SKA3 Targeted Therapies in Cancer Precision Surgery: Bridging Bench Discoveries to Clinical Applications—Review Article," *International Journal of Surgery* 110, no. 4 (2024): 2323–2337, https://doi.org/10.1097/JS9.0000000000001123.

85. C. Tortora, A. Di Crosta, P. La Malva, et al., "Virtual Reality and Cognitive Rehabilitation for Older Adults With Mild Cognitive Impairment: A Systematic Review," *Ageing Research Reviews* 93 (2024): 102146, https://doi.org/10.1016/j.arr.2023.102146.

86. B. F. Kocyigit, M. I. Assylbek, and M. Yessirkepov, "Telerehabilitation: Lessons From the COVID-19 Pandemic and Future Perspectives," *Rheumatology International* 44, no. 4 (2024): 577–582, https://doi.org/10.1007/s00296-024-05537-0.

87. N. Tohanean, P. Tucan, O.-M. Vanta, et al., "The Efficacity of the NeuroAssist Robotic System for Motor Rehabilitation of the Upper Limb—Promising Results From a Pilot Study," *Journal of Clinical Medicine* 12, no. 2 (2023): 425, https://doi.org/10.3390/jcm12020425.

88. O. Ljungqvist, M. Scott, and K. C. Fearon, "Enhanced Recovery After Surgery," *JAMA Surgery* 152, no. 3 (2017): 292–298, https://doi.org/10.1001/jamasurg.2016.4952.

89. M. Pilkington, G. Nelson, C. Cauley, et al., "Development of an Enhanced Recovery after Surgery Surgical Safety Checklist through a Modified Delphi Process," *JAMA Network Open* 6, no. 2 (2023): e2248460, https://doi.org/10.1001/jamanetworkopen.2022.48460.

90. K. E. Rollins, D. N. Lobo, and G. P. Joshi, "Enhanced Recovery After Surgery: Current Status and Future Progress," *Best Practice and Research Clinical Anaesthesiology* 35, no. 4 (2021): 479–489, https://doi.org/10.1016/j.bpa.2020.10.001.

91. U. O. Gustafsson, M. J. Scott, M. Hubner, et al., "Guidelines for Perioperative Care in Elective Colorectal Surgery: Enhanced Recovery after Surgery (ERAS®) Society Recommendations: 2018," *World Journal of Surgery* 43, no. 3 (2018): 659–695, https://doi.org/10.1007/s00268-018-4844-y.

92. G. R. Joliat, K. Kobayashi, K. Hasegawa, et al., "Guidelines for Perioperative Care for Liver Surgery: Enhanced Recovery After Surgery (ERAS) Society Recommendations 2022," *World Journal of Surgery* 47, no. 1 (2022): 11–34, https://doi.org/10.1007/s00268-022-06732-5.

93. A. Willner, C. Teske, T. Hackert, and T. Welsch, "Effects of Early Postoperative Mobilization Following Gastrointestinal Surgery: Systematic Review and Meta-Analysis," *BJS Open* 7, no. 5 (2023): zrad102, https://doi.org/10.1093/bjsopen/zrad102.

94. R. Tazreean, G. Nelson, and R. Twomey, "Early Mobilization in Enhanced Recovery After Surgery Pathways: Current Evidence and Recent Advancements," *Journal of Comparative Effectiveness Research* 11, no. 2 (2022): 121–129, https://doi.org/10.2217/cer-2021-0258.

95. E. H. J. Hulzebos, Y. Smit, P. Helders, N. L. U. van Meeteren, and E. H. J. Hulzebos, *Preoperative Physical Therapy for Elective Cardiac Surgery Patients* (Cochrane Database of Systematic Reviews, 2012).

96. T. E. Carver, N. Mayo, R. E. Andersen, and G. S. Zavorsky, "Pilot Investigation to Evaluate Changes in Exercise Capacity Following a Prehabilitation Intervention Among Seriously Obese Patients Awaiting Bariatric Surgery," *Canadian Journal of Diabetes* 35, no. 2 (2011): 149, https://doi.org/10.1016/S1499-2671(11)52045-3.

97. S. Agarwal, T. J. Hoogeboom, E. Oosting, et al., "Therapeutic Validity and Effectiveness of Preoperative Exercise on Functional Recovery After Joint Replacement: A Systematic Review and Meta-Analysis," *PLoS ONE* 7, no. 5 (2012): e38031.

98. Y. Hijazi, U. Gondal, and O. Aziz, "A Systematic Review of Prehabilitation Programs in Abdominal Cancer Surgery," *International Journal of Surgery* 39 (2017): 156–162, https://doi.org/10.1016/j.ijsu.2017.01.111.

99. P. Duro-Ocana, F. Zambolin, A. W. Jones, et al., "Efficacy of Supervised Exercise Prehabilitation Programs to Improve Major Abdominal Surgery Outcomes: A Systematic Review and Meta-Analysis," *Journal of Clinical Anesthesia* 86 (2023): 111053, https://doi.org/10.1016/j.jclinane.2023.111053.

100. J. Froehlich, "Proud and Visible as Occupational Therapists," *The American Journal of Occupational Therapy* 46, no. 11 (1992): 1042–1044, https://doi.org/10.5014/ajot.46.11.1042.

101. G. Sweeney and K. Nichols, "Stress Experiences of Occupational Therapists in Mental Health Practice Arenas: A Review of the Literature," *International Journal of Social Psychiatry* 42, no. 2 (2016): 132–140, https://doi.org/10.1177/002076409604200207.

102. R. A. Mack, C. E. Stanton, and M. R. Carney, "The Importance of Including Occupational Therapists as Part of the Multidisciplinary Team in the Management of Eating Disorders: A Narrative Review Incorporating Lived Experience," *Journal of Eating Disorders* 11, no. 1 (2023): 37, https://doi.org/10.1186/s40337-023-00763-6.

103. J. Fawor, N. Hancock, J. N. Scanlan, and D. E. Hamilton, "Supporting Self-Determination in Mental Health Recovery: Strategies Employed by Occupational Therapists," *Australian Occupational Therapy Journal* 71, no. 1 (2023): 88–101, https://doi.org/10.1111/1440-1630.12913.

104. R. Hatton, A. Wallis, A. Chew, M. Stanley, and A. Smith, "Return to Work and Cancer: Perspectives of Occupational Therapists," *Australian Occupational Therapy Journal* 68, no. 4 (2021): 298–307, https://doi.org/10.1111/1440-1630.12727.

105. J. Picotin, M. Beaudoin, S. Hélie, A.-É. Martin, and A. Carrier, "Occupational Therapists as Social Change Agents: Exploring Factors That Influence Their Actions," *Canadian Journal of Occupational Therapy* 88, no. 3 (2021): 231–243, https://doi.org/10.1177/00084174211022891.

106. K. Lee, J.-H. Kim, H. Hong, et al., "Deep Learning Model for Classifying Shoulder Pain Rehabilitation Exercises Using IMU Sensor," *Journal of NeuroEngineering and Rehabilitation* 21, no. 1 (2024): 42, https://doi.org/10.1186/s12984-024-01343-8.

107. P. Falkowski and K. Jeznach, "Simulation of a Control Method for Active Kinesiotherapy With an Upper Extremity Rehabilitation Exoskeleton Without Force Sensor," *Journal of NeuroEngineering and Rehabilitation* 21, no. 1 (2024): 22, https://doi.org/10.1186/s12984-024-01316-x.

108. L. B Aledi, C. D. Q. Flumignan, V. F. M. Trevisani, and F. Miranda Jr, "Interventions for Motor Rehabilitation in People With Transtibial Amputation due to Peripheral Arterial Disease or Diabetes," *Cochrane Database of Systematic Reviews* 2023, no. 6 (2023).

109. M. Heimer, S. Schmitz, M. Teschler, et al., "eHealth for Maintenance Cardiovascular Rehabilitation: A Systematic Review and Meta-Analysis," *European Journal of Preventive Cardiology* 30, no. 15 (2023): 1634–1651, https://doi.org/10.1093/eurjpc/zwad145.

110. S. T. J. McDonagh, H. Dalal, S. Moore, C. E. Clark, and R. S. Taylor, "Cochrane Corner: Centre Versus Telemedicine Approaches to Cardiac Rehabilitation," *Heart* 110, no. 1 (2024): 7–10, https://doi.org/10.1136/heartjnl-2023-322640.

111. T. Tsuge, N. Yamamoto, S. Taito, T. Miura, D. Shiratsuchi, and T. Yorifuji, "Efficacy of Telerehabilitation for Patients After Hip Fracture Surgery: A Systematic Review and Meta-analysis," *Journal of Telemedicine and Telecare* 31, no. 2 (2025): 174–183.

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

112. M. A. van Egmond, R. H. H. Engelbert, J. H. G. Klinkenbijl, M. I. van Berge Henegouwen, and M. van der Schaaf, "Physiotherapy with Telerehabilitation in Patients With Complicated Postoperative Recovery After Esophageal Cancer Surgery: Feasibility Study," *Journal of Medical Internet Research* 22, no. 6 (2020): e16056.PMID: 32515742.

113. C. T. L. Li, G. K. N. Hung, K. N. K. Fong, P. C. Gonzalez, W. S-h, and H. W. H. Tsang, "Effects of Home-Based Occupational Therapy Telerehabilitation via Smartphone for Outpatients After Hip Fracture Surgery: A Feasibility Randomised Controlled Study," *Journal of Telemedicine and Telecare* 28, no. 4 (2020): 239–247, https://doi.org/10.1177/1357633X20932434.

114. T. I. Usichenko, S. Kuchling, T. Witstruck, et al., "Auricular Acupuncture for Pain Relief After Ambulatory Knee Surgery: A Randomized Trial," *Canadian Medical Association Journal* 176, no. 2 (2007): 179–183, https://doi.org/10.1503/cmaj.060875.

115. R. L. Roberts, A. W. Hanley, and E. L. Garland, "Mindfulness-Based Interventions for Perioperative Pain Management and Opioid Risk Reduction following Surgery: A Stepped Care Approach," *The American Surgeon™* 90, no. 5 (2022): 939–946, https://doi.org/10.1177/00031348221114019.

116. G. Sbruzzi, S. A. Silveira, D. V. Silva, C. C. Coronel, and R. D. M. Plentz, "Estimulação Elétrica Nervosa Transcutânea no Pósoperatório de Cirurgia Torácica," *Revista Brasileira De Cirurgia Cardiovascular* 27, no. 1 (2012): 75–87.PMID: 22729304.

117. C. Gillis, O. Ljungqvist, and F. Carli, "Prehabilitation, Enhanced Recovery After Surgery, or Both? A Narrative Review," *British Journal of Anaesthesia* 128, no. 3 (2022): 434–448, https://doi.org/10.1016/j.bja.2021.12.007.

118. C. M. Saunders, "Breast Surgery: A Narrative Review," *Medical Journal of Australia* 217, no. 5 (2022): 262–267, https://doi.org/10.5694/mja2.51678.

119. E. M. Minnella, F. Carli, and W. Kassouf, "Role of Prehabilitation Following Major Uro-Oncologic Surgery: A Narrative Review," *World Journal of Urology* 40, no. 6 (2020): 1289–1298, https://doi.org/10.1007/s00345-020-03505-4.

120. S. Fredericks and T. Yau, "Clinical Effectiveness of Individual Patient Education in Heart Surgery Patients: A Systematic Review and Meta-Analysis," *International Journal of Nursing Studies* 65 (2017): 44–53, https://doi.org/10.1016/j.ijnurstu.2016.11.001.

121. A. R. Choi and P. B. Greenberg, "Patient Education Strategies in Cataract Surgery: A Systematic Review," *Journal of Evidence-Based Medicine* 11, no. 2 (2018): 71–82, https://doi.org/10.1111/jebm.12297.

122. S. J. Chapman, J. A. Helliwell, M. D. S. Lonsdale, J. P. Tiernan, and D. G. Jayne, "Patient Education About Recovery After Colorectal Surgery: Systematic Scoping Review," *Colorectal Disease* 22, no. 12 (2020): 1842–1849, https://doi.org/10.1111/codi.15337.

123. Y. Farid, L. Fernando Botero Gutierrez, S. Ortiz, et al., "Artificial Intelligence in Plastic Surgery: Insights From Plastic Surgeons, Education Integration, ChatGPT's Survey Predictions, and the Path Forward," *Plastic and Reconstructive Surgery – Global Open* 12, no. 1 (2024): e5515, https://doi.org/10.1097/GOX.0000000000005515.

124. D. A. Rigberg and J. Jim, "Considerations for the Application of Artificial Intelligence in Vascular Surgical Education," *Seminars in Vascular Surgery* 36, no. 3 (2023): 471–474, https://doi.org/10.1053/j.semvascsurg.2023.07.004.

125. B. C. Hamilton, M. I. Dairywala, A. Highet, et al., "Artificial Intelligence Based Real-time Video Ergonomic Assessment and Training Improves Resident Ergonomics," *American Journal of Surgery* 226, no. 5 (2023): 741–746, https://doi.org/10.1016/j.amjsurg.2023.07.028.

126. S. Wu, M. Tang, J. Liu, et al., "Impact of an AI-Based Laparoscopic Cholecystectomy Coaching Program on the Surgical Performance: A Randomized Controlled Trial," *International Journal of Surgery* 110, no. 12 (2024): 7816–7823, https://doi.org/10.1097/JS9.0000000000001798.

127. T. Igaki, D. Kitaguchi, H. Matsuzaki, et al., "Automatic Surgical Skill Assessment System Based on Concordance of Standardized Surgical Field Development Using Artificial Intelligence," *JAMA Surgery* 158, no. 8 (2023): e231131, https://doi.org/10.1001/jamasurg.2023.1131.

128. Y. Koçer Tulgar, S. Tulgar, S. Güven Köse, et al., "Anesthesiologists' Perspective on the Use of Artificial Intelligence in Ultrasound-Guided Regional Anaesthesia in Terms of Medical Ethics and Medical Education: A Survey Study," *The Eurasian Journal of Medicine* 55, no. 2 (2023): 146–151.

129. U. N. Isleem, B. Zaidat, R. Ren, et al., "Can Generative Artificial Intelligence Pass the Orthopaedic Board Examination?," *Journal of Orthopaedics* 53 (2024): 27–33, https://doi.org/10.1016/j.jor.2023.10.026.

130. A. R. Katwaroo, V. S. Adesh, A. Lowtan, and S. Umakanthan, "The Diagnostic, Therapeutic, and Ethical Impact of Artificial Intelligence in Modern Medicine," *Postgraduate Medical Journal* 100, no. 1183 (2024): 289–296, https://doi.org/10.1093/postmj/qgad135.

131. S. Law, B. Oldfield, and W. Yang, "ChatGPT/GPT-4 (Large Language Models): Opportunities and Challenges of Perspective in Bariatric Healthcare Professionals," *Obesity Reviews* 25, no. 7 (2024): e13746, https://doi.org/10.1111/obr.13746.

132. V. Akbari Kordkheyli, M. Rashidi, Y. Shokri, et al., "CRISPER/CAS System, a Novel Tool of Targeted Therapy of Drug-Resistant Lung Cancer," *Advanced pharmaceutical bulletin* 12, no. 2 (2022): 262–273.

133. J. Risse, M. Krzemien, J. Schnalke, and T. Heinemann, "Towards Ethical Drug Pricing: The European Orphan Genomic Therapies Fund," *Gene therapy* 31, no. 7 (2024): 353–357, https://doi.org/10.1038/s41434-024-00452-2.

134. C. Brokowski and M. Adli, "CRISPR Ethics: Moral Considerations for Applications of a Powerful Tool," *Journal of Molecular Biology* 431, no. 1 (2019): 88–101, https://doi.org/10.1016/j.jmb.2018.05.044.

135. B. Parent, B. Gelb, S. Latham, A. Lewis, L. L. Kimberly, and A. L. Caplan, "The Ethics of Testing and Research of Manufactured Organs on Brain-Dead/Recently Deceased Subjects," *Journal of Medical Ethics* 46, no. 3 (2020): 199–204, https://doi.org/10.1136/medethics-2019-105674.

136. S. Marinelli and A. Del Rio, "Beginning of Life Ethics at the Dawn of a New Era of Genome Editing: Are Bioethical Precepts and Fast-Evolving Biotechnologies Irreconcilable?," *La Clinica Terapeutica* 171, no. 5 (2020): e407–e411.PMID: 32901783.

137. J. C. L. Ong, S. Y. Chang, W. William, et al., "Ethical and Regulatory Challenges of Large Language Models in Medicine," *Lancet Digit Health* 6, no. 6 (2024): e428–e432, https://doi.org/10.1016/S2589-7500(24)00061-X.

138. S. M. Pressman, S. Borna, C. A. Gomez-Cabello, S. A. Haider, C. Haider, and A. J. Forte, "AI and Ethics: A Systematic Review of the Ethical Considerations of Large Language Model Use in Surgery Research," *Healthcare (Basel, Switzerland)* 12, no. 8 (2024): 825.PMID: 38667587.

27662098, 2026, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/EXP.20240417 by CochraneChina, Wiley Online Library on [11/08/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License