






Digital regenerative medicine and surgery pedagogy for virtual learning in the time of COVID-19

Saranya P Wyles^{1,2,3} , Fredric B Meyer^{4,5} , Richard E Hayden^{1,6} ,
Isobel A Scarisbrick^{1,7}  & Andre Terzic^{*,1,3,8,9} 

¹Center for Regenerative Medicine, Mayo Clinic, Rochester, MN, USA

²Department of Dermatology, Mayo Clinic, Rochester, MN 55905, USA

³Department of Molecular Pharmacology & Experimental Therapeutics, Mayo Clinic, Rochester, MN 55905, USA

⁴Mayo Clinic Alix School of Medicine, Rochester, MN 55905, USA

⁵Department of Neurologic Surgery, Mayo Clinic, Rochester, MN 55905, USA

⁶Department of Otolaryngology, Mayo Clinic, Phoenix, AZ 85054, USA

⁷Department of Physical Medicine & Rehabilitation, Mayo Clinic, Rochester, MN 55905, USA

⁸Department of Cardiovascular Medicine, Mayo Clinic, Rochester, MN 55905, USA

⁹Department of Clinical Genomics, Mayo Clinic, Rochester, MN 55905, USA

*Author for correspondence: Tel.: +1 507 284 2747; Fax: +1 507 284 3431; terzic.andre@mayo.edu

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“Regenerative therapies, primed to transform clinical practice, have transitioned from the orbit of conceptual learning into core medical curriculum for next-generation healthcare providers. Disrupted by the COVID-19 pandemic, the regenerative medicine classroom, designed to introduce these concepts early in medical training, adopted a virtual learning platform – a portal for global learners.”

Regeneration, aimed to restore form and function, has captured human imagination dating back to ancient times and the enduring myth of Prometheus, the Greek god whose immortal liver was feasted on day after day by Zeus' eagle [1]. Today, regenerative therapies, primed to transform clinical practice, have transitioned from the orbit of conceptual learning into core medical curricula for next-generation healthcare providers. Inaugural courses have been deployed to introduce regenerative medicine concepts and practices early in medical education training [2]. However, the coronavirus disease 2019 (COVID-19) pandemic has abruptly disrupted traditional modes of on-site medical education, mandating new solutions. Accordingly, a virtual learning platform – a new portal for global learners – has been rapidly deployed, informed by the plasticity of the regenerative medicine and surgery pedagogy.

Evolving regenerative medical education

Propelled by the prospect of ‘cure-seeking’ disease management, regenerative therapies have matured from conceptual principles to the rigor of scientific bench and randomized clinical trials [3]. Increasingly, adoption into practice has driven a prompt incorporation of regenerative medicine educational programs into mainstream medical training, deployed to school next-generation healthcare providers [4]. The ‘Regenerative Medicine and Surgery Course’ at Mayo Clinic, now in its seventh year of formal existence, is one such example [2]. This curriculum for medical students offers a comprehensive educational experience that encompasses discovery, development and delivery of next-generation patient care modalities aimed to address root cause of disease. At its core, the patient-centric curricular focus offers medical students the opportunity to participate in concept-based and practice-applied sciences across the progressive discovery–translation–application continuum. While syllabus plasticity is reinforced with annual course iterations responding to the evolving nature of regenerative sciences, the 2020 version of the course was met with the challenge of navigating content delivery during the COVID-19 pandemic. This crisis ultimately served as the catalyst to usher clinical medical education to innovate and utilize online learning, ultimately enabling a broader global reach and ensuring expanded connectivity [5–7].

Amidst COVID-19 social distancing guidelines, academic medical centers adopted major themes of medical education management including leveraging remote or decentralized modes of curriculum delivery, maintaining the integrity of formative assessments while restructuring patient-contact components and developing action plans for flipped classrooms and small-group active learning [8–10]. In alignment with these strategies, the ‘Regenerative Medicine and Surgery Course’ transitioned core patient-centric education modules, including regenerative medicine principles, regenerative procedures, clinical-grade biomanufacturing and regulatory science, bench-to bedside translation and integration of delivering regenerative patient care, into a virtual platform. Enabled by the digital teaching modality, continual underpinning of regenerative sciences across the clinical training spectrum allowed trainees to enhance their medical science foundation and explore the vanguard of proven trends and validated, standardized regenerative solutions [11].

Meeting the needs of the virtual learner

The mission to provide greater patient access to regulated regenerative therapies requires addressing the gap in healthcare education [12,13]. Indeed, educating a specialized workforce that can distinguish safe and validated regenerative options is necessary to transform standard-of-care practices in a responsible manner [14,15]. Based on the ‘from the patient to the patient’ paradigm, a regenerative medicine and surgery curriculum has been established with new competencies in disruptive regenerative innovation using the preclinical discovery, clinical translation and practice application model, while ensuring that best practices are implemented [2]. Under the COVID-19 restrictions, the Mayo Clinic ‘Regenerative Medicine and Surgery Course’, composed of multifaceted course content across medical and surgical specialties, was rapidly adopted and implemented in the ‘new way’ 2020 digital format, comprehensive of clinical trial highlights and patient experiences, digital didactic lectures, virtual human anatomy laboratory sessions, live-broadcasted video tours of clinical-grade manufacturing facilities, trainee career panels and social networking sessions (Figure 1).

Teleconferences and webinars are a useful means for continuous medical education [16] and the COVID-19 pandemic allowed this modality to rise as the cardinal means to provide interactive didactics in clinical education [17–19]. Medical schools and residencies have now utilized applications such as Google Hangouts [20], Skype [21], Zoom [22], WebX [23], Slack [24], Blackboard Collaborate [25] or other virtual meeting multimedia [26] to deliver clinical trial highlights, regenerative care patient experiences, team-facilitated journal clubs, small group discussions and self-directed learning with free open access medical education [27]. Such digital resources allowed the ‘Regenerative Medicine and Surgery Course’ participants to engage with faculty lecturers including physicians, physical therapists, nursing staff, scientists, regulatory and business development specialists, ethicists and external visiting scholars. Students also learned about regenerative care counseling directly from patients participating in ongoing clinical trials. Furthermore, an online video library of simulated regenerative telemedicine patient consults provided access to common questions from the consult service, allowing medical trainee preparedness to address patient inquiries. Subject matter experts provided small group discussion feedback to reinforce clinical outcomes and key concepts. These opportunities allowed course participants to foster mentor identification and student-faculty sponsorship despite the distance learning environment.

Beyond didactic lectures, the virtual course incorporated hands-on regenerative procedures including ultrasound-guided joint injection and surgical demonstrations for degenerative conditions. While anatomy education relies on face-to-face teaching and cadaveric dissections, rapidly devised innovative adaptation to the virtual platform allowed educators to present enhanced prerecorded, narrated procedures with cutting-edge regenerative technologies (e.g., 3D bioprinting) [28]. Other interactive sessions included live-broadcasted video tours of clinical-grade manufacturing, showcasing product development, cell manufacturing, quality assurance and scale-up/out for allogeneic and autologous regenerative therapies. Group learning was further facilitated by online information sharing and utilizing hashtags (e.g., #RegMedClass) [29], allowing students to post questions, review journal articles and engage with the virtual community.

The present iteration of the Mayo Clinic ‘Regenerative Medicine and Surgery Course’ engaged over 50 transatlantic learners including medical students, graduate students, postbaccalaureate students, residents and clinical fellows. Online postcourse assessment (n = 41 out of 53 completed the survey) indicated that 100% of the students would recommend this course to other medical trainees; 88% stated that this course impacted how they envision practicing medicine; 75% stated that this course has influenced them to pursue research in regenerative medicine; and 70% stated that the class model was unaffected by the virtual platform (Figure 1). The envisioned digital regenerative medicine and surgery pedagogy ushers a virtual horizon for facilitated knowledge dissemination

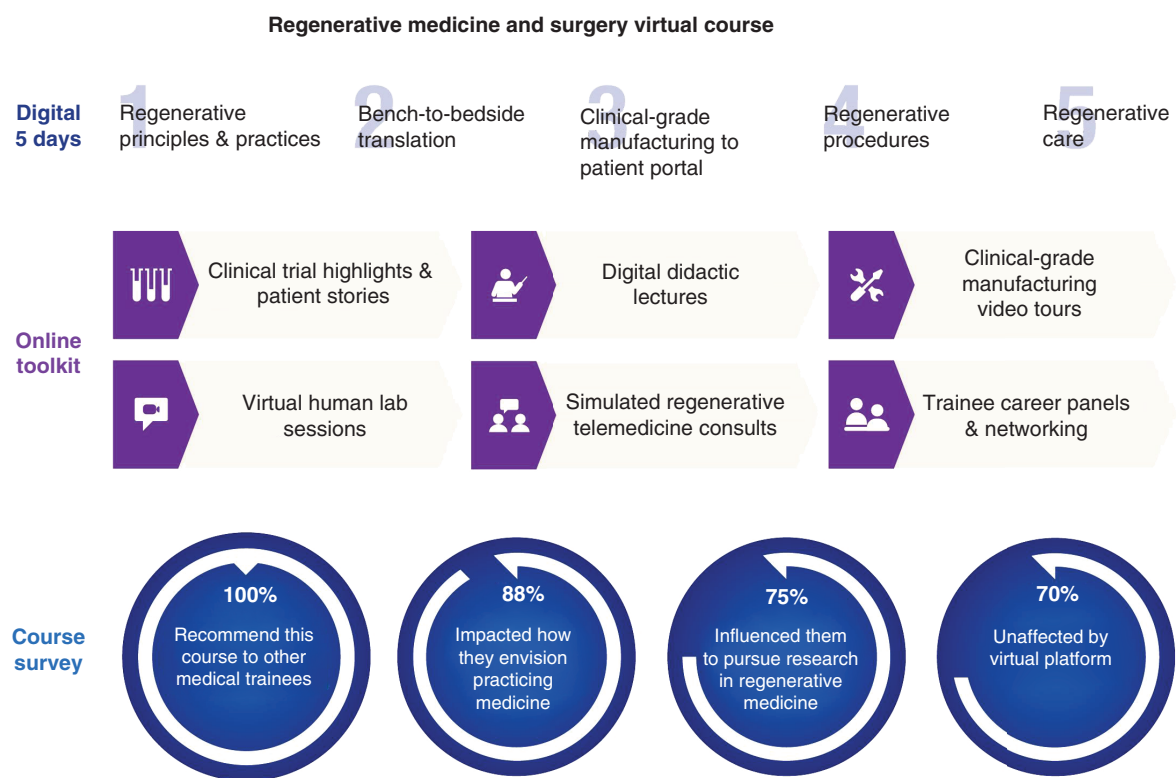


Figure 1. Digital education blueprint for regenerative medicine and surgery curriculum. Challenges related to medical training during COVID-19 prompted rapidly re-envisioned, contemporary learning modalities. This virtual regenerative medicine and surgery course, composed of multifaceted content across medical and surgical specialties, exemplifies accelerated deployment in the 'new way' 2020 digital format, comprehensive of clinical trial highlights, patient stories, digital didactic lectures, virtual human anatomy laboratory sessions, video tours of clinical-grade manufacturing, trainee career panels and networking sessions, catalyzing a global community of learners and ensuring expanded connectivity.

with increased connectivity across broader learner communities, encompassing graduate, nursing and advanced healthcare professionals [30].

Conclusion

Integration of the regenerative medicine discipline across medical school training is an educational priority contributing to modern trends in education-driven practice advancement. Challenges related to training during the COVID-19 pandemic prompted rapidly re-envisioned, contemporary training modalities integral to efforts aimed to expand physician-investigators pools in this growing field. Indeed, the online learning platform allowed for accelerated digital course deployment and stood up virtual classrooms in days, catalyzing a global community of next-generation learners and ensuring expanded connectivity. The acquired experience now offers a digital foundation applicable to a spectrum of educational tracks needed in the build-out of the specialized workforce of tomorrow.

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