MODEL HEALTHCARE FOR ALL

The unacceptably high cost of healthcare calls for new technologies to make medicine more accessible and affordable as well as to face the challenges of an aging population. However, the overarching tenet remains patient safety, and government regulations ensure that medical products and treatments will do no harm despite the large human variability. But at what price? The years-long R&D/approval cycle drives up medical costs. The good news is that the industry benefits significantly from global rapid technology innovation, leveraging high-tech advances from miniaturization to wireless to intelligent software.

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As healthcare organizations labor toward profit, they embrace simulation tools and methodologies not just to speed development but to ensure extreme product safety and reliability — a goal of 100 percent efficacy. Computer modeling and simulation (in silico testing) are revolutionizing the field: The methodology provides valuable insights upfront, bringing earlier product launch and greater return on investment through reduced reliance on animal studies and bench testing. Innovative companies are now leveraging simulation as a gateway to personalized medicine. (See article on page 3.)

Cardiovascular

The cardiovascular community is under pressure to develop minimally invasive products/treatments that are safer and cheaper than traditional ones. Computer models are remarkably accurate in predicting how an aortic aneurysm stent would perform in specific patients, proven by a Cardiatis investigation. Such strategic use of simulation amplifies development efforts and validates products to regulatory agencies, insurance companies and investors (page 6).

A multiphysics approach ensures model fidelity by incorporating blood flow, cardiovascular structures and electronic/mechanical device performance. An aortic valve manufacturer used simulation to better understand implant forces — which are impossible to measure accurately — in treating elderly high-risk patients with aortic valve stenosis (page 10).

University of Sheffield clinical cardiologists investigated non-invasive modeling of the pressure drop across a stenosis. The hospital study, which yielded a quantitative metric in deciding whether to perform invasive procedures or medicate patients with less severe conditions, reached high diagnostic accuracy at 97 percent (page 13).

Orthopedics

To innovate while minimizing patient risk, orthopedics — once focused solely on individual bones — now takes a comprehensive skeletal approach that includes behavior of motion, such as walking, as well as multiphysics effects of MRI on implants.

Simulation is even proving its worth in surgical planning. Biomechanical modeling can reduce surgery duration and patient risk in treating infants with skull disorders (page 17). Another clinical group adopted simulation to optimize component positioning based on predicted joint reaction forces. Results showed that at the six-month point, the computer-assisted surgery group had superior walking ability (page 19).

Diagnostic Equipment

R&D is moving beyond mere medical imaging to diagnosis and even automatic treatment when warranted. Portable wearable devices track body functions and deliver data electronically. Fast and safe innovation requires multiphysics simulations to evaluate performance by modeling a complete system: wireless device, antenna and their interactions with the human body. Synapse engineers increased the range of its product by a factor of five while saving an estimated three months of development time (page 23). Devices with remote-charge batteries must be SAR-compliant, and government agencies accepted Medtronic's simulation results as proof that the recharging system does not locally heat soft tissue (page 26).

Medical and Hospital Supplies

Electronics prevail in medical supplies — even in hospital beds that automatically measure body functions. Starkey Hearing Technologies leveraged simulation to improve wireless hearing-aid performance while saving time and money by quickly iterating through design alternatives (page 30).

Artificial organs can save lives, since many patients die while awaiting a donor kidney, lung or heart. Multiphysics systems simulation is essential for smaller, less-complex artificial organ design (page 35).

Pharmaceutical

In silico modeling accelerates innovation for pharmaceutical and biotech companies. It empowered FluidDA researchers to better visualize pulmonary functions for faster, less expensive clinical testing of respiratory drugs. The approach demonstrates drug effectiveness using fewer patients, with the potential to cut years from the development process and reduce costs by hundreds of millions of dollars (page 39). A manufacturer of single-use biopharmaceutical mixing equipment leveraged simulation to save hundreds of thousands of dollars by significantly reducing the need to build and test prototypes (page 45).

The future of healthcare is bright, thanks in part to multiphysics simulation and in silico clinical trials. Within 10 years, experts predict that up to 60 percent of testing will be conducted via computer. To achieve this, companies will need to democratize simulation use among engineers of varying skill levels, with the combined result of accelerating product development. It is a win–win situation: health care to the masses, profits to keep the industry in business.