BIOMECHANICS PRIORITIES CONFERENCE
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Priority Statement Title: Making surgical procedure simulation real through biomechanics

Priority Statement Code: CJ2A

Domain: Cell/Tissue

Priority Statement

Background and Relevance

The current mandate of surgical education involves providing decision-making and technical skills training that will help compensate for decreasing amounts of surgical time, patient exposure, and hands-on mentored teaching. Simulation-based minimally invasive surgical (MIS) training has been shown to effectively enhance clinical outcomes in less time compared to traditional training. But these simulators are built upon approaches that make them only situationally valid. In addition, the overwhelming majority of surgeries are and will continue to be performed through open access incisions, i.e. not minimally invasive, yet there are no simulators to address this need.

The constraints upon technical surgical training that is traditionally centered upon operating room (OR) time has led to a number of alternative approaches to teaching, particularly anatomic surrogates such as animal tissue, cadavers, and inanimate materials. Whether the animal tissue is *in vitro* or *in vivo*, or whether cadavers or inanimate models are used, all current approaches have problems with cost, infrastructure, versatility, and likeness to live human tissue and organs. Common to all of these alternatives to OR-based learning are the following:

- They are typically based in dedicated training facilities and are used primarily when trained faculty are available to mentor
- Assessment is a largely subjective process, not the uniform objective assessment of skill attainment desired by educators and licensing bodies
- There are limitations on the variability of geometry and mechanical response characteristics as well as the breadth of representation of specific pathologies that can be achieved with these anatomic surrogates

Surgical simulation addresses many of these shortcomings. Surgical simulators may be used independently of faculty and because they automatically collect data on user activity, they are ideally suited as platforms for objective assessment of technical surgical ability.

It is clear that simulators are important and they have a sustained development effort behind. But to meet their potential, they need to be based on a solid computational biomechanics foundation and assessed with rigorous engineering evaluations. There is enormous need here for biomechanists to fill this gap.

The same information and the simulations that they will enable can be used for many areas beyond training such as device/procedure prototyping, patient-specific procedure rehearsal, and intraoperative procedure guidance.

Objectives

Multiple stages in the development process of surgical simulation need to be addressed through the participation of multiple disciplines

- Surgeries of interest need to be decomposed in terms of the mechanics of the interactions of the surgeons upon the tissue. This requires surgery, education, and biomechanics experts.
- The behavior of composite structures, such as entire muscles/joints or blood vessels/nerves connected to surrounding structures, in response to mechanical manipulation need to be measured for use in design and evaluation of simulators. This is primarily to province of biomechanics.

- Standard methods of simulator construction and assessment need to be established that satisfy the scientific rigor of biomechanists and the clinical utility of surgeons. This requires surgery, education, human factors, and biomechanics experts

Recommended Actions

- Leverage off of the strength of biomechanics' concentration in the musculoskeletal area by focusing on muscle, bone, and joint centric procedures.
- Initially address procedures that have high clinical value, difficulty in learning (such as requiring patients or live animals), and significant patient risk, e.g. compartment syndrome
- Establish fundamental experimental approaches that should be followed at a minimum to characterize procedures such that sufficient biomechanics knowledge is known to design and build effective simulations with a specific procedure as the driver for the effort
- Establish standard approaches to assessing simulators that use the data collected in the procedure characterization effort and establish a standard means of describing correctness of a simulation