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Science Highlight

Modeling of Human Tissue Damage and Cellular Injury in Electric Shock

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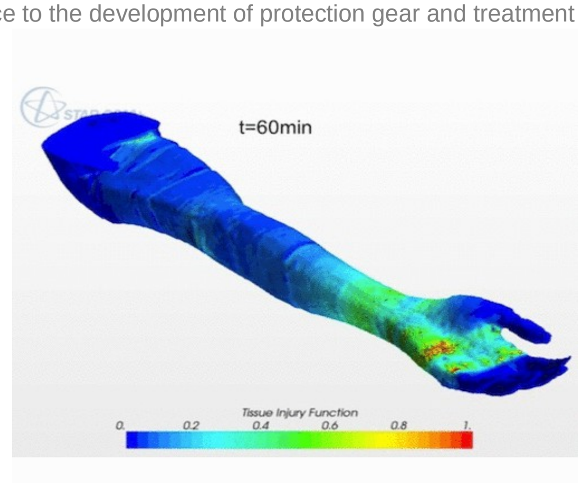
Electrical trauma can result from direct contact with a variety of electricity sources, such as exposed parts of electrical appliances or wiring, high-voltage power lines and lightning. While some electrical shocks may result in minor burns, there still may be serious internal damage, which can produce a complex pattern of injury and clinical manifestations. High-voltage electrical trauma produces some of the most devastating physical injuries. A typical high-voltage electric shock cause massive damages in skeletal muscles, blood vessel and peripheral nerves that can lead to repeated removal of the injured tissues, extensive rehabilitation and limb amputation rates as high as 75% . Due to the variability of electrical shock scenarios, it is almost impossible to precisely diagnose the patient's tissue injury at the time of admission. Therefore, a computer-aided electric shock simulation will provide important insight into the tissue damages and improve the clinical management for electrical trauma.

Tissue injury mechanisms due to electric shock include Joule heating and cell membrane electroporation. We describe a worst-case hand-to-hand high-voltage electrical trauma model that takes both mechanisms into account. Electric field and Joule heating along the tissues in the human upper limb are presented by solving Laplace and Pennes' bioheat equations in a 3-D mesh. Our simulation shows a 7.2k-Volt electric shock with duration of 1-second can cause severe muscle damage in distal forearm. We also evaluated several post-shock treatment methods and found that ice cooling applied immediately post shock reduces the chance of tissue damage by more than 70%. The analysis of electric shock provides insight into the mechanisms of tissue damage and guidance to the development of protection gear and treatment of electric trauma.



Technical challenges and approaches

The model is built upon a 1-mm-resolution human upper extremity MRI image and implemented with thermal and electrical properties of various tissues. We use Beagle to calculate the electric field and temperature distribution of 2.5 million elements over more than 7000 time steps by solving multiple electromagnetic and bioheat equations. The simulation also shows the kinetics of tissue damage caused by plasma membrane electroporation and Joule heating from the shock phase to one hour post shock.

Resouces:

Beagle Wiki
Get detailed usage information from the Beagle team

Beagle Support
Contact the Beagle experts for help

Globus
Get started moving files to/from Beagle using this fast service

Other CI resources
Learn about other computing resources available at the Computation Institute

Training:

Intro to Beagle2
February 19th, 1:30PM
Room 240A, at the Computation Institute of the University of Chicago

Topics will include:

- General overview of Beagle2's team and the computational institute
- Overview of Beagle2's Cray XE6 system architecture
- Basic access and navigation operations
- Using compilers and applications
- Appropriate use of local and network filesystems
- Submitting jobs and monitoring jobs
- Data transfer
- Specific topics requested by users (e.g., using R or Matlab on Beagle2)

Beagle2 Events To learn more about Beagle2 trainings.

Conclusion

- We presented an electrical shock trauma model (including both electroporation and Joule heating) for worst-case hand-to-hand or hand-to-feet scenarios on 3-d human upper limb mesh
- For a 7.2kV 60-Hz AC shock with 1-second duration, electroporation is the dominant mechanism for muscle damage in shock phase whereas thermal injury dominates the post-shock phase.
- Ice cooling, if applied immediately, is effective in reducing tissue injury

Beagle Upgrade Completed!

We are proud to announce the substantial hardware upgrades provided by our successful Beagle2 grant application. The upgrade would consist of:

- Addition of 2.24 PB of raw disk space in two new DDN cabinets for a total of 2.84 PB of raw storage (~2.1 PB total usable).
- All compute blades upgraded from 6-core Magny Cours processors to 8-core Abu Dhabi processors, increasing core count per node from 24 to 32.
- All compute blades upgraded from 32GB to 64GB per node.
- Added 4 compute nodes with nVidia GPU processors.

Beagle Related Publications

Baxa MC1, Haddadian EJ2, Jumper JM3, Freed KF4, Sosnick TR5
Loss of conformational entropy in protein folding calculated using realistic ensembles and its implications for NMR-based calculations

Proc Natl Acad Sci U S A. 2014

Urgent and important request for RECENT publications made using Beagle

In this new grant period, allocations will be reassigned based upon many factors, including previous use. To have a list of recent publications made possible by Beagle2 is essential to understand the role of Beagle in the university research environment. Feel free to send a complete list of papers that explicitly acknowledge Beagle, including papers that we might have received already.

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