Can mathematics help predict burns evolution and reduce animal experiments?

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Severely burned skin can exhibit serious contractions that may negatively impact the mobility of joints of patients. In order to improve burn care, it is important to understand the underlying biophysical processes in burned skin. In order to link theory to clinical and in-vitro observations, it is necessary to quantify the underlying theory.

For this reason, a mathematical modelling framework has been developed in terms of algebraic (differential) relations. The talk deals with mathematical simulation methods for post-burn evolution of skin. In the modelling framework, one considers the balance of momentum, cells, collagen and chemokines. The balances are represented in terms of partial differential equations, of which the solution is approximated by the use of numerical techniques.

These techniques combine finite element discretization, time integration and root finding problem to solve the resulting nonlinear algebraic equations. Since many of the input parameters are unknown, uncertainty assessment is done in order to obtain output results in terms of estimations of probability distributions.

The main output variables are the wound area and total dermal stress energy as a function of time after injury, since these parameters quantify the extent of dermal contraction. In order to speed up the simulation so that clinicians are granted access to computed results, machine learning is used to reproduce simulation results.

The talk will show several clinical implications from the mathematical framework. Mathematical details will not be elaborated on.