A Biomechanical Model of the Upper Airways for Simulating Laryngoscopy

M. A. F. RODRIGUES[a], D. GILLIES[a,*] and P. CHARTERS[b]

[a]*Department of Computing, Imperial College of Science, Technology and Medicine, 180 Queen's Gate, London SW7 2BZ, United Kingdom;* [b]*Department of Anaesthesia, Walton Hospital, Rice Lane, Liverpool L9 1AR, United Kingdom*

(Received 5 December 1999; In final form 22 May 2000)

This paper describes a three-dimensional finite element model of the human upper airways during rigid laryngoscopy. In this procedure, an anaesthetist uses a rigid blade to displace and compress the tongue of the patient, and then inserts a tube into the larynx to allow controlled ventilation of the lungs during an operation. A realistic model of the main biomechanical aspects involved would help anaesthetists in training and in predicting difficult cases in advance. For this purpose, the finite element method was used to model structures such as the tongue, ligaments, larynx, vocal cords, bony landmarks, laryngoscope blade, and their inter-relationships, based on data extracted from X-ray, MRI, and photographic records. The model has been used to investigate how the tongue tissue behaves in response to the insertion of the laryngoscope blade, when it is subjected to a variety of loading conditions. In particular, the mechanical behaviour of the soft tissue of the tongue was simulated, from simple linear elastic material to complex non-linear viscoelastic material. The results show that, within a specific set of tongue material parameters, the simulated outcome can be successfully related to the view of the vocal cords achieved during real laryngoscopies on normal subjects, and on artificially induced difficult laryngoscopy, created by extending the upper incisors teeth experimentally.

Keywords: Deformable models; Simulation; Upper airways; Laryngoscopy