# *BIOMEDICAL ENGINEERING TALKS*

## CHALLENGES ASSOCIATED WITH TISSUE CUTTING IN A SURGICAL TRAINING SIMULATOR

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**INTRODUCTION:** A virtual reality-based laparoscopic surgery simulator is an important training tool for laparoscopic surgeons, and has significant advantages over other training methods. Generally this laparoscopic surgery simulator consists of the following elements: visual graphics, haptic instruments and associated haptic software, and training scenarios. The visual graphic effects are associated with a number of instruments/anatomy interactions, including cutting a number of anatomical objects with scissors. In this paper, a new method for cutting of soft tissues will be proposed and the associated challenges will be outlined.

The main aim of the virtual surgical simulation system is to simulate the laparoscopic surgical process. The simulation system needs to include geometry modeling, physical modeling, computational modeling, collision detection, deformation, and surgical manipulation such as cutting and rendering. Cutting is an important and common manipulation within surgery. In the simulation of cutting an organ, it is considered to be a virtual object, which is made up of thousands of polygons or elements. Thus cutting changes the way that the polygons are joined.

Others have addressed cutting by:

1. Removing the elements that collide with the cutting tool [1].This removal destroys the material from the virtual organ and does not obey the mass conservation law.
2. Subdividing the colliding elements [2].This method is more realistic, but the number of simulated elements increases, thus increasing the time needed for remodeling.
3. Separating the elements instead of destroying or dividing them [3].This method can generate irregular surfaces and these surfaces do not actually follow the cutting tool path.

**PROPOSED METHOD FOR CUTTING:** Cutting is performed after determining that a cut effective collision has taken place. It occurs progressively as the user moves through an individual element of the object and needs to be accurate. The proposed cutting is therefore divided into the following steps. Instruments (scissors, grasper, and diathermy) are selected. An object is grasped. Collision (instrument-organ collision) is detected. Segmental finite element (FE) model of the uterine tube segment is cut. The first cut state from initial contact to cut completion is computed using FE model static computation. The visual graphics are remodeled to accommodate cut segment. The second cut state from the first cut to the second cut completion is computed using the FE model-static computation. The visual graphics are remodeled to accommodate the cut segment. The third cut state is computed using the FE model-static computation. The visual graphic is remodeled to accommodate cut. This sequence is continued until cutting is completed. Interpolation is used as required to establish visual realism.

**DISCUSSION & CONCLUSIONS:** The main objective of this simulator is to provide a training tool for surgeons. Each feature introduced into the simulator needs to be evaluated in the context of the simulator as a whole. The most important requirements for a surgical simulation are speed and realism. A major challenge is to maximize both. Another challenge is handling the complexity of the modeling, where each step in the cutting process requires constant remodeling and thus is time consuming. The proposed method for cutting appears to offer great potential.

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## AUDITORY EVOKED POTENTIAL ANAESTHESIA MONITORING DESIGN CONSTRAINTS

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**INTRODUCTION:** This paper establishes the setting and some basic design principles for a more cognitively sensitive and responsive anaesthesia monitoring (AM) system. An experimental AEP-based AM system was designed and clinically tested to assess AM system design practicality and constraints within the context of an operating theatre environment, with particular emphasis on the tracking of awareness [1].

**METHODS:** An ethics approved study was conducted across 20 patients undergoing anaesthesia during surgical procedures. Individual latency band measures of the middle-latency auditory evoked potential (MLAEP) were assessed for suitability as measures of depth of consciousness (CO) or unconsciousness (UNCO), amongst a group of anaesthetised surgical patients. CO (Events 1-3; 11-13) and UNCO (Events 4-10) periods, as defined by conventional verbal prompts and visual observations, were compared by way of t-test statistical analysis. AEP data showed that significant ($P<0.05$) values were derived for all AEP power, amplitude and differential computed AEP latency time bin (LTB) correlates.

**RESULTS:** The averaged MLAEP traces [2] were computed across all patient study events 1-13 (Fig 2) representative of start of study, pre-anaesthesia, start of anaesthesia, loss of response to verbal command (Fig 1 top trace), pre-incision, time of incision (Fig 1 center trace), 15 s post incision, 5 m post-incision, end of anaesthesia (Fig 1 lower trace), 3 min pre-eye-opening, 1 min pre-eye-opening, eye-opening, and study end.

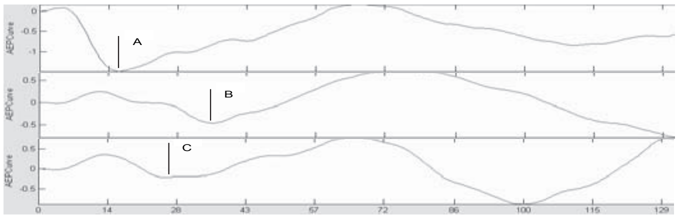


**Figure 1**

**ANALYSIS:** The following parameters were computed and results then graphically presented as a means to assess CO and UNCO values [2]. AEP grand mean waveform data was grouped into the individual LTBs designated: Na;15 25ms, Pa;25-35 ms, TP41;35-45 ms; Pb/P1;45-55 ms, N1;80-100 ms,<N1;0-80 ms,>N1;80-140 ms, and MLAEP;0-140 ms. LTB analysis included: standard deviation for AEP power distribution (Fig 2 left), AEP Differential analysis (Fig 2 center), and BIS (Aspect Monitoring) bispectral index were also graphed (Fig 2 right).

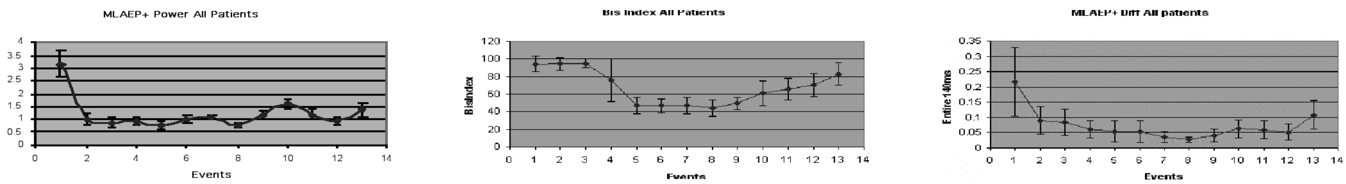


**Figure 2**

Figure 2 presents a sequence of average data waveform traces demonstrating MLAEP signal morphology changes by way of comparative markers, denoted A, B and C. Marker A (16 ms latency per top trace), B (35 ms latency percenter trace), and C (27 ms per lower trace) demonstrate MLAEP latency changes reflecting light, deep and emergence from anaesthesia, respectively.

**DISCUSSION & CONCLUSIONS:** The outcomes of this study showed that significant design constraints and limitations were evident upon close assessment of the experimental AEP-based anaesthesia depth of consciousness monitoring system [2]. It appears from the context of this clinical study and also the growing body of literature on this subject, that analysis techniques capable of tracking AEP morphological changes during anaesthesia are an essential design requirement where enhanced cognition or awareness detection is required. However, while sophisticated MLAEP tracking analysis is essential, it is also clear that successful validation studies across large and variant data-bases, covering a comprehensive range of anaesthetic types and patient groups must be conducted.

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## TECHNIQUES TO CHARACTERISE GENERALIZED BODY VIBRATIONS IN RESPONSE TO MECHANICAL STIMULI

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