Infusion Device Characteristics Related to User Error during Programming and Operation Determined by Finite State Modeling

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Introduction : The advent and proliferation of potent, short acting intravenous agents for anesthesia and critical care has driven the use of microprocessor based infusion devices [1]. Incidents involving drug infusion devices are relatively common [2,3] . Attempts to study device related incidents have identified "programming error", but not sought out contributory factors. We demonstrate here a new approach to aid the study of errors involving infusion devices. This approach is based on explicit modeling of device states.

Methods : As part of initial work for an ongoing investigation of infusion devices, we systematically programmed two infusion devices, (device "A") and (device "B") to produce a comprehensive view of programming permutations. The "menuspace" thus explored was then modeled as a finite state machine in order to illustrate the variety of programming routes.

Results : The models reveal the substantial device complexity of "B". The finite state machine representation contains over 2200 discrete screen states with 10,000 possible key press permutations. The final model represents collections of states as groups of programming screens, within which multiple program states are contained. The programming complexity is in contrasts with the simple appearance of this and similar devices, e.g. the finite state diagram of device "A" which was an order of magnitude less complex, and substantially different in structure. Complexity is hidden from the user; programming pathways are not marked. At various stages it is unclear which functions are available, which keys are active, or what their functions are. Remarkably, the operations manuals for the devices present simplified descriptions. They are formatted to show a single path to an infusion goal, and do not identify alternate pathways.

Discussion : Device complexity is an integral part of both infusion devices studied. This complexity arises from a need for flexibility in infusion schemes. The simple appearance of the devices and the carefully delineated programming paths in the operations manuals do not reproduce the complexity of the device itself. Instead they disguise the pathway variability at each step of the programming sequence.

The complete menuspace demonstrated in the finite state models for the two devices suggests that operating sequences may be varied. Because the "B" device effectively hides this complexity from the user, users are likely to become "lost in menuspace" during operation.

The method described is useful for characterizing their complexity and aiding studies of "user error". It may be generalized for use with virtually any medical device.

1. Hunt-Smith J, et al. *Anaesth Intensive Care* 27: 260-4, 1999.
2. Cook RI, et al. *J Cardiothorac Vasc Anesth.* 6:238-44, 1992.
3. Cook RI, Woods DD. *J Clin Anesth.* 8:29S-37S, 1996.

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