Advanced Informatics in The Intensive Care Unit: Possibilities and Challenges

-- Neil A Halpern, MD, FCCM --

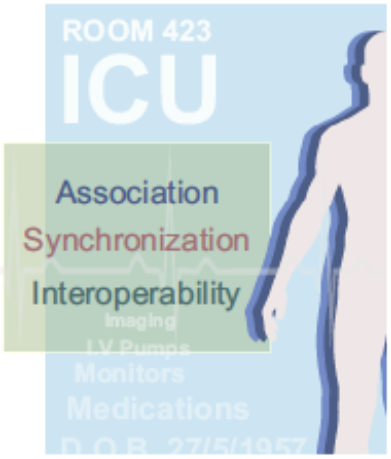
The Intensive Care Unit (ICU) that is loaded with advanced informatics (Smart ICU) technologies centers the ICU patient in the middle of a vast computer network. The smart ICU electronically integrates the ICU patient with all aspects of care including medical devices, ICU and hospital data, the electronic medical record (EMR), caregivers, and medical and administrative applications. Patient and device data can then be transformed into actionable information, transmitted to pertinent clinical systems and caregivers, displayed in compelling formats, and utilized for local and remote ICU monitoring.

Connectivity Envelope

The creation of a smart ICU requires the development of a connectivity envelope around the patient. The first step in this five part process is the installation in each patient room of a wired and wireless infrastructure that is integrated with the hospital's network. The second step is the attachment of auto identification (Auto-ID) tags on all data sources (i.e. devices and personnel) that enter the patient room to facilitate their tracking. The third step is the addition of adaptors and/or computers to the data output ports of the medical devices to connect these devices to the envelope. The fourth step is the installation of receivers (wired or wireless access points, readers, scanners and multi-mode and multi-port concentrators) to track the tagged data sources and capture data and alarms from the medical devices. The last step is the placement of middleware (servers and applications) on the hospital network to utilize the data originating from the ICU patient room and perform the required tasks. The middleware may be categorized as FDA Class I medical device data systems (MDDS) or FDA Class II devices. MDDS capabilities include data storage, management, transfer, display and conversion of proprietary device to standardized formats (interoperability). FDA Class II applications are more sophisticated than the MDDS and provide active patient monitoring and alarms.

Challenging Concepts

Three elements are critical to the success of advanced ICU informatics. The first is the "association" of all data sources with the ICU patient. This is accomplished either by linking the data and devices with the patient's location (location-centric) or the patient's name/unique identifier (patient-centric). The patient-centric solution is preferred because the data is "permanently" attached to the patient regardless of patient's location. However, the patient-centric solution is more complicated to implement than location-centric and requires an active interface to the hospital's bed management system. The second element is synchronization of time across all bedside devices and



systems to achieve a stable electronic flow sheet and medical record. However, time synchronization is challenging as each of the many devices in the ICU room, as well as the middleware on the network, may have their own internal time clocks that are not easily coordinated. The third aim is to attain "interoperability" between data sources, middleware and the medical record. Interoperability is the process of conversion and alignment of the proprietary data output of medical devices with industry standards thereby allowing data to be recognized and understood across systems. To date, interoperability has not been accomplished across the spectrum of health care devices because many of the device manufacturers have not prioritized interoperability as one of their goals. Concomitantly, the concept of interoperability is opaque to clinicians who, therefore, do not press for its implementation.

Advanced ICU Applications

Herein, we will address four applications that are very useful in the ICU setting. The first addresses the management of the many device-generated alarms that commonly overload and mentally fatigue the ICU staff. Although alarms can be partially dealt with at the device level; a systematic approach is needed to deploy ICU alarms that are meaningful to staff and patient care. Intelligent alarm systems capture device alarms and convert them into actionable information by filtering and transmitting them to dedicated receivers and personnel. More advanced alarm systems can even analyze device-generated, raw patient data and create personalized alarms. The second application utilizes device servers that sit above the medical devices to create "virtual" device communities. Such middleware allows for global device monitoring (local telemedicine), alarm transmission, report generation and remote access for vendors to troubleshoot their systems and update their software. The third application is the deployment of smart displays that enable clinicians to rapidly identify changes in patient conditions. Smart displays merge data from many sources (bedside devices and EMR), process this data through advanced algorithms, and present the integrated data in a visually compelling manner that "speaks" to the clinicians and proactively alerts them to previously unforeseen or potentially forthcoming problematic clinical scenarios. The fourth application

utilizes Real Time Locating Systems/ Solutions (RTLS) to improve management and workflow of tagged assets. RTLS may be used in real-time or historically to locate assets (i.e. devices, patients and staff), monitor device utilization, harmonize device distribution and repair, control product inventory, and create data and reports for future purchases. RTLS can also be integrated with existing ICU systems. For example, infection control may be improved through the monitoring of staff compliance with hand washing using automated tracking of tagged staff in conjunction with RTLS sensors incorporated into hand-washing dispensers. RTLS and nurse-call systems can also be combined to locate and communicate with the nearest tagged caregiver if a patient activates the nurse-call system seeking assistance.

Putting the Smart ICU Together

New devices and informatics systems offer great advances and functionalities as compared to the existing technologies; these systems are thus quite enticing to clinicians. Technology vendors also market their new systems as "plug and play" implying an easy integration with existing ICU and hospital devices and middleware. Our long term experience of analyzing and implementing new technologies in our ICU suggests that the successful selection and incorporation of advanced informatics technologies is not simple at all. A disciplined process that fosters deliberate and controlled assessment and testing of new technologies (i.e. medical devices or middleware) in a simulation environment that mimics the ICU workplace in its entirety is required. Of course, the ICU teams need to clearly visualize and conceptualize their end-goals for advanced ICU informatics at the beginning of smart ICU design to make sure that the ICU is getting the systems and applications that are beneficial.

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