Case Study
Hospital Integrates Remote, Real-Time Monitoring Data from Isolation Unit

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The pervasiveness of infectious diseases is compelling hospitals to build isolation units, which requires the redesign of workflows, visualization of monitoring data beyond the bedside, and integration of data from all sources in the unit into the electronic health record (EHR). A case example from Texas Children’s Hospital (TCH) in Houston illustrates the challenges of meeting these demands. This article describes the solution that was realized as part of the case experience and offers guidance on how to build a similar unit; enable remote, real-time monitoring; and ensure that all necessary data integrate into the EHR.

Case Example: Pediatric Isolation Unit
TCH is the largest pediatric hospital in the country. In November 2014, in response to numerous infectious diseases, including Ebola, being treated at the hospital, TCH began designing the nation’s first pediatric isolation unit. TCH’s West Campus, which is approximately 25 miles from the hospital’s main campus, was selected as the home for this eight-bed isolation unit.

Planning the isolation unit and enabling remote monitoring required careful consideration of issues related to clinical workflow: how clinicians and technical staff access data, where data originate in the care environment (specifically the points of collection and devices used), where data are sent, and what workflows are used to enable effective care.

Patients in this unit need to be separated from the clinical teams. Before accessing patients, team members must put on bio-level safety gear. Multiple monitoring devices are located in the patient rooms, and this bulky safety gear makes viewing patient data, and in some cases even accessing patients, difficult. As a result, bedside patient evaluations are challenging. TCH therefore determined that the most effective way for the care team to evaluate a patient’s condition was to do it remotely.

The information required to evaluate patients and construct the most appropriate treatment plan varies according to the care team. For example, nursing staff have different use cases than consulting physicians and therefore need different views into patient information. To accommodate these needs, TCH requested the following aspects in the design of the isolation unit.

• Outside the unit
  – The ability to look in and see the patient

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The ability to see all medical devices connected to the patient
- Inside the unit
  - The ability to view the entire context of the patient room (while considering that safety gear compromises visibility)
  - The capacity to view multiple patients simultaneously from a centralized station, including seeing their vital signs, waveforms, and EHR information, as well as the ability to evaluate them visually via a video feed
- From a consult room, giving physicians the ability to view patient history and provide real-time monitoring in order to better evaluate treatment plans
- A use case to address family and nurse communication with the patient in the isolation unit

Bedside data sources included a monitor for high acuity (physiologic monitor) connected to the patient, a ventilator potentially hooked up to the patient, a nurse call interface in the unit for communication directly with the patient, and the EHR (Epic).

To evaluate endpoints, the care team required alarms to be distributed to a secondary notification system. Remote displays also were needed in various viewing stations, including remote monitoring and central stations for all bedside devices. These scenarios were a departure from traditional monitoring, for which a majority of bedside devices are not integrated with each other or with central stations. This traditional setup limits the viewing of data. Complete ventilator and cardiology data can only be viewed at the bedside, with only a portion of the data available from a central nursing station.

After performing its workflow evaluation, TCH studied other sites with remote units to identify known gaps in solutions that would need to be addressed for the isolation unit. These included being able to gather data across multiple devices and incorporate patient video into the workflow. TCH then coordinated with third-party vendors to develop a solution. The details of that solution are described in the following sections.

Staff training also was considered as part of the implementation process. The goal in designing the training was to make it as seamless as possible. TCH simulated various workflows with clinical stakeholders during the evaluation process to test and validate user workflow requirements. Training on the selected workflows then was provided to team members, including physicians and nursing staff. The novel approach to this integration project was that the final product was designed to fit into existing clinical EHR workflows rather than requiring training that was separate from that for EHR implementation. The patient monitor integrations were designed specifically for this project so that the clinical users could visualize near-real-time waveforms and alarms remotely and as an extension of the EHR portal.

Implementing the Remote Consult Room

A remote consult room was used for physician evaluation of patients in the isolation unit (Figure 1). For this remote evaluation to be effective, physicians required access to complete patient records (i.e., labs, medications, procedures, notes), real-time access to monitoring data (i.e., vitals, alarms, waveforms from the physiologic monitor and ventilator), and a video feed that enabled visual evaluation of patients.

TCH identified three key technology infrastructure needs to meet these objectives:
1. A means to view patient context and remote monitoring, preferably within the Epic patient monitor to maintain consistency.
2. A way to facilitate remote visual and audio communication with the patient, which would be enabled through a video-monitoring solution. This solution would be accessible to both the care team and family.
3. A care team communication solution, whereby a nurse in the nursing station could communicate with the patient and/or a nurse in the room and vice versa. To achieve this, smart panel technology was considered. The smart panel is a wall-mounted liquid-crystal display monitor with programmable buttons that can help automate aspects of clinical workflow (e.g., start a protocol, call nurses).
The monitoring system used by TCH provides a web-based, high-level snapshot of a patient’s condition that concisely displays data. To optimize the system for its isolation unit, TCH sought to better understand other users’ experiences. Users expressed two main challenges:

1. Some felt that patient data might be outdated. Sometimes only user-validated data were available, whereas customers wanted access to real-time data and physiological waveforms. Having this real-time information is vital to effective decision making.

2. Because consulting clinicians could not see the patients, users expressed a need for video integration to be embedded along with the snapshot of the patient’s condition.

Integrating a Mix of Solutions

These challenges noted above required multiple solutions. When TCH began to define the requirements for its isolation unit, a mixture of vendor solutions was selected to help realize their workflow and use cases. The hospital had two reasons for choosing solutions that fit within the existing networking infrastructure. First, the unit was being built within an existing hospital; therefore, the rooms already had wired connectivity and power. Second, the solution needed the capability to expand throughout the hospital, as remote monitoring has many use cases apart from isolation units. That said, integrating this technology in the isolation unit presented a unique challenge.

As part of infection control, all objects inside an isolation unit room are incinerated after use. All bedside devices, integration tools, and monitors are removed and burned, then new devices are installed as the room is prepared for the next patient. The need to repeatedly replace hardware would result in considerable expense for a remote monitoring solution in an isolation room. One key takeaway from this integration effort was to create a solution that relied much more heavily on networked software.

Figure 1. Configuration of the pediatric isolation unit at Texas Children’s Hospital. Physicians evaluate patients via a consult room located in the adjoining acute care unit.
In addition to these infection control–related concerns, TCH had two other key considerations when selecting components. First, because of the hospital’s future intent of scaling the solution across the organization and preparing for future configurations with different patient devices, the components had to be vendor neutral. Second, any components used in the solution needed to integrate with existing clinical workflows within the EHR system.

TCH used the Sickbay clinical intelligence platform with the PatMon traditional app (Medical Informatics Corp [MIC], Houston, TX) to enable viewing of real-time cardiac waveforms from the physiologic monitor along with ventilator data and settings, which would be embedded in the patient monitor. The medical device integration products Neuron with Smartlinx (Capsule; now Qualcomm Life, San Diego, CA) was used to help enable ventilator integration, which would push data to both Sickbay and the EHR. Vidyo video conferencing (Vidyo, Hackensack, NJ) was used for remote video access, Connexall middleware system (Connexall, Boulder, CO) was used for real-time alarms and nurse call event distribution to the care team.

TCH then had to engineer a solution to fit this new and unique workflow. TCH worked with MIC to create flexible remote monitoring that could be embedded in different scenarios, including the patient monitor. The hospital needed data to be streamed in real time. It also required data syncing across monitoring devices and the ability to fuse data from various monitoring devices (e.g., cardiac monitors, ventilators). It also wanted to view patients’ historical data for their entire length of stay and across connected devices.

MIC integrated monitoring data into the Sickbay Clinical Platform, thereby enabling real-time data and waveforms to be pulled from the physiologic monitors. Ventilators were connected through Neuron, then streamed via the SmartLinx server with multifeed, high-fidelity data interfaces into Sickbay. All data were visualized and transformed with Sickbay in order to be embedded in the patient monitor (Figure 2). To ensure security, Sickbay’s solution is kept entirely within the hospital’s firewall, accessible only through the hospital’s internal network.

The data were normalized across various devices. Time synchronization with low latency enabled physicians to receive full-resolution data in real time.

**Key Takeaways**

One key reason for TCH’s success in this initiative was its effective collaboration with various vendors, ensuring that all parties were accountable for their respective deliverables. In these scenarios, action steps must happen sequentially. A delay in one item can cause delays throughout the entire project.

Although this initiative had specific considerations owing to the realities of a patient isolation unit, the following lessons learned are transferable to other remote monitoring solutions:

- **Ventilator integration with cardiac devices.** Flexible bedside device integration is needed whenever a patient is placed on multiple devices.
- **Display of real-time cardiac waveforms, along with other physiologic data from other devices.** This display is needed whenever a patient is at risk of arrest, which can be a major reason for remote monitoring in central stations or by specialists. Other bedside devices (e.g., ventilators) complete the clinical picture; therefore, gaining remote access to these devices and to cardiac signals is critical.
- **Embedded remote monitoring within EHR workflow.** An integrated display with all relevant data presented in a familiar clinical application can reduce training time. Specifically, Epic has a product called Epic Monitor that provides summary results of a patient pulled from the patient monitor. It is generally displayed on a 40-inch screen at the viewing location. In this case, MIC created a embedded widget that allows the user to see the near-real-time streaming data from Sickbay from the bedside monitoring device in the patient room, as well as see it displayed in this high-level patient summary on the 40-inch monitor.
Conclusion

Fully functional as of October 2015 after only 11 months of implementation, TCH’s isolation unit is ready to handle any pediatric isolation case from around the country. Critical data can be remotely accessed securely in real time from the patient monitor or any web-enabled device on the hospital’s network. Success in the pediatric isolation unit also has led to hospitalwide discussions regarding other applications for real-time monitoring. These applications include remote consults by clinicians and specialists within the same hospital system, 24-hour surveillance for postsurgery patients, and remote surveillance by electrophysiologists.

Figure 2. View of physiologic monitoring data from the electronic health record. Abbreviations used: ABP, arterial blood pressure; CO₂, carbon dioxide; ECG, electrocardiogram; etCO₂, end-tidal carbon dioxide; HR, heart rate; SpO₂, peripheral capillary oxygen saturation.