Chapter 16. Operating Room Integration and Display Systems: Brief Review (NEW)

Fang Sun, M.D., Ph.D.

Introduction

Patient monitoring is one of the central tasks in operating rooms (ORs). Because of the increasing use of advanced technologies in surgical procedures, today’s ORs are commonly crowded with freestanding devices, support systems, and monitors. In addition to the traditional monitors that continuously present the patient’s hemodynamic, respiratory, and electrophysiological signals, many innovative devices recently introduced into the OR feature their own platforms for data display. These devices may fall into one of four categories:  

- Surgical machine-controlled applications (e.g., robotics, minimally invasive surgery, video-endoscopic surgery, master-slave systems)
- Designated diagnostic and real-time navigation devices (e.g., magnetic resonance imaging, computed tomography, three-dimensional ultrasound)
- Information technology (IT) applications generating a real-time connection between the OR and the hospital medical record archives (e.g., picture archiving and communication systems [PACS], videos, electronic medical records (EMRs), hospital information systems, and other laboratory data)
- Telecommunication and teleconferencing systems connecting the OR in real time with other medical centers

The increasing use of these devices leads to a congestion of data displays in the OR, compels OR staff members to increase the time devoted to monitoring the displays, and may divide their attention between monitoring and other tasks. Meanwhile, the proliferation of freestanding devices and displays in the OR makes coordination difficult. Surgeons, nurses, and anesthesiologists have their own perioperative devices or systems on which to focus. Human coordination of multiple electromechanical devices may lead to misunderstandings and delay action.

As some experts have commented, what is currently lacking in most ORs is a high-level overview of all the information that is already available in the room. The lack of integration of patient data makes ORs inefficient, overcrowded, and less safe. When patient data are not displayed to caregivers in an integrated fashion, OR staff have to frequently with multiple displays to obtain updates and exert control over the various devices at their disposal.

OR integration is an emerging technology that has the potential to address the long-standing problem of segregated data display in ORs. This technology organizes and consolidates patient data for clinicians during a surgical procedure. This chapter focuses on the latest form of the technology, which features a centralized data display platform.
What Are the Practices for Integrating Operating-Room Display Systems?

An OR is integrated if users can control the routing of audio/video (AV) signals from a central location. These AV signals can originate from within an OR (e.g., endoscopes, wall-mounted cameras) or outside an OR (e.g., PACS, AV feed from another OR). Depending on configuration, an OR integration system may also permit centralized control of certain clinical devices (e.g., insufflators and electrocautery units) and nonclinical equipment (e.g., lighting and room climate controls). Some OR integration systems may allow signals to be sent outside the room (e.g., to a conference room or to a central display used by the OR scheduling nurse) or exchange data with an EMR system.

Current-generation OR integration systems offer a range of capabilities. ECRI Institute has identified at least 10 vendors that offer products meeting the basic definition of OR integration (i.e., with centralized control of AV routing in the OR).

Centralized display of consolidated data. OR integration technology continues to evolve as new features are added. One of the latest developments in the field is the consolidation of real-time patient data from different devices and systems (e.g., physiologic monitors, anesthesia systems) for display on a “dashboard” format single screen that can be viewed simultaneously by all clinicians in the OR. We believe this new development represents the future of OR integration; thus, we focus this chapter exclusively on OR integration systems that can display consolidated data on a single screen. We exclude conventional OR integration systems that lack the capacity to present data in a centralized, single-screen format.

Two studies published by ECRI Institute in 2008 identified at least two vendors that offered OR integration systems featuring a centralized repository/display of consolidated data sent from a number of monitors and devices in real time. These two systems are the OR-Dashboard™ (LiveData, Inc., Cambridge, MA, U.S.) and the ICIS (integrated clinical information system) Dashboard (Global Care Quest, Inc., Aliso Viejo, CA, U.S.). Both systems have the capacity to interface with numerous medical devices, patient monitors, and information systems without encountering compatibility problems. Data may be collected from patient progress logs, OR scheduling software, real-time vital signs, anesthesia systems, medical infusion pumps, radio frequency identification tracking systems, PACS, EMRs, clinical laboratory systems, in-room cameras, endoscopic systems, clinical notes and rounding lists, bidirectional video conferencing, and audio note recording. The data can be displayed on large, wall-mounted, flat-panel screens and on accessory monitors in the OR. Both systems allow clinicians to monitor time trends of various waveforms, such as respiration, blood pressure, and cardiac activity.

The central display of the OR-Dashboard changes to reflect one of four procedural stages: case setup, time out (safety pause), intraoperative, and closing. Case setup mode displays information such as surgical supplies and blood availability. The time out mode assists the surgical team in verifying patient and case information. Intraoperative mode displays information such as physiologic status, fluid status, and current readings from ventilators and infusion pumps. Closing mode includes information on equipment counts, postanesthesia care unit assignment, and family waiting status. This display arrangement is intended to improve situation awareness during the surgery.

Used with other products provided by LiveData, the OR-Dashboard allows videoconferencing between the surgical team and other departments to monitor procedures remotely or consult specialists throughout the hospital in real time. The OR-Dashboard can
also securely archive all case data, including video, using various device and information protocols to permit case review after the surgery.\textsuperscript{7,8} With additional software provided by Global Care Quest, the ICIS Dashboard provides secure access to the collected patient data in real time through wireless mobile devices, including personal digital assistants and “smart” phones that clinicians can use where a wireless connection is available.\textsuperscript{7}

**Contribution to operative and perioperative safety.** OR integration technology with centralized data display can potentially help improve operative and perioperative safety in several ways. First, the technology allows easy, just-in-time access to patient information from disparate devices or systems that is often unseen, unrealized, or unused.\textsuperscript{8,9} Increased access to this information may improve team situation awareness (TSA, i.e., the task- and team-oriented knowledge held by everyone in the team and the collective understanding of the unfolding situation).\textsuperscript{8,10} TSA is one of the critical factors in OR teamwork that can affect patient safety and quality of care. Augmented TSA can improve communication among clinical personnel and thus help reduce the number of medical errors.\textsuperscript{5,8,11,12}

Second, the integration of previously isolated information sources may open new opportunities for decision support and augment vigilance.\textsuperscript{8} For example, allergy information from the hospital information system may alert the team to not administer certain drugs to the patient and, thus, prevent harmful drug-related adverse events. Information from the laparoscopic insufflator can inform the team of impending asystole from insufflation. Information from the location tracking system may help the surgical team check the accuracy of patient identity. Integration with the order-entry system can help update the team on workflow and resource acquisition such as pathology, radiology, and the blood bank. The order information can be continuously displayed throughout the operative period to decrease uninformed or delayed decisions.

Additionally, the OR integration technology provides the ability to flexibly change the source or destination of an AV signal without requiring the cumbersome process of reconfiguring direct links between sources and destinations each time such a change is needed.\textsuperscript{6} This ability might decrease the risk of medical errors in the reconfiguration process. OR integration may also generate other opportunities for improving patient safety. For example, the technology might allow real-time, remote consultation from experts outside of the OR.\textsuperscript{6} The technology could enhance patient data collection during the surgery and decrease stale or duplicate data. These data can be analyzed later for the purpose of improving patient safety. The technology may also have a positive psychological effect on clinical personnel, making them feel more comfortable and more confident that things are going well.\textsuperscript{10}

**How Have Integrated Operating-Room Display Systems Been Implemented?**

We identified several sources that described issues related to the design, planning, or installation of integrated OR systems (with or without centralized data display).\textsuperscript{5,6,14-17} In particular, two studies provided practical guidance on the implementation of integrated ORs. One of the studies offered step-by-step instruction for addressing the equipment and construction needs for OR integration.\textsuperscript{15} The study outlined the technical considerations for in-room integration, extended AV integration, and equipment control. The study also provided a detailed list of equipment and specifications required for OR integration.
The second study discussed the technical issues that must be addressed when installing
integrated ORs. The issues included controlling the images, integrating team members, pre-
construction planning, working with vendors, and managing the final project phases. It was not
feasible to provide additional details about these studies in this brief review. Readers can refer to
the original studies for detailed instructions on implementing integrated ORs.

**Data about costs.** According to an ECRI Institute study, as of October 3, 2007, a LiveData OR-
Dashboard system costs about $150,000. Total system costs can vary widely depending on the
features that a hospital requests and the number of systems installed at a facility. Facilities
could also face significant additional costs to integrate new systems into their existing IT
infrastructure. Similar cost information for the ICIS Dashboard was not reported.

**Effect of context on effectiveness.** We identified a survey of 17 surgeons and 9 scrub nurses
from a single hospital that evaluated their satisfaction after 2 years of use of integrated ORs. The
surgeons and scrub nurses agreed that a great degree of education and a cultural change were
needed to use the system in a correct and complete way. However, we were not able to verify
whether the integrated ORs described in the study had the centralized data display feature. We
did not identify any other study that evaluated the effect of context on the effectiveness of an
integrated OR and centralized display systems in improving patient safety.

**What Have We Learned About Integrating Operating-Room
Display Systems?**

Despite all of the rationales supporting the adoption of OR integration and display systems,
published evidence to validate the effect of this technology on patient safety is rare. Researchers
face many practical obstacles in designing and conducting clinical trials that could deliver a
hard-and-fast measurement of that effect. For example, surgical patients comprise a
heterogeneous population, making it difficult to draw firm conclusions from any studies.
Additionally, because the incidence of medical errors and other adverse events is rather low
(from the statistical perspective), detecting a significant improvement in safety outcomes
typically requires a very large number of patients. Recruiting enough patients to conduct a good
study would be difficult.

Our search identified only one case report that described the experiences of a hospital in
implementing an OR integration system with centralized display (called “wall of knowledge” in
the review). The authors provided their opinion-based assessment of the system. The perceived
benefits of the system included easy access to a patient’s vital signs for surgeons during the
operation, improved staff handoffs, reduction of clutter in the OR, improved teaching function,
and timely data reporting. No patient safety outcomes were reported in the study.

In the survey that evaluated the satisfaction of 17 surgeons and 9 scrub nurses from 1 hospital
after 2 years of using integrated ORs, the clinicians agreed that integrated ORs—using a
digitalized video acquisition system, boom-mounted devices, and multiple displays—can be very
effective in increasing quality of care, reducing risk, and shortening surgery time. Scrub nurses
were particularly confident that medical device control could reduce the confusion inside the OR
and reduce the number of setting errors. However, as mentioned previously, based on the
information reported in the study, we were not able to verify whether the integrated ORs had the
centralized display feature.
In theory, if an OR integration system or its centralized display stop functioning appropriately or fail entirely, clinicians in the OR could receive delayed or misleading information about the patient. Clinical decisions based on such information could lead to patient harm; however, our search did not identify any study that reported data on harms caused by integrated OR centralized display systems.

Note that for this chapter, we reviewed only studies relevant to patient safety issues. We did not review studies that focused solely on management issues (e.g., the effects of a display system on OR efficiency or staff scheduling).

Conclusions and Comment

OR integration with centralized data repository/display represents the latest technology development in the OR setting. While the technology might help improve patient safety, evidence to demonstrate the technology’s benefits in improving safety outcomes is lacking. Given the many practical obstacles in designing and conducting empirical studies to test the benefits of this technology, decisions on its adoption will continue to be based on rationales rather than hard evidence in the near future. Patient safety is only one of the factors that are considered in the decisionmaking process. Other factors, such as the technology’s potential to improve OR efficiency and productivity, need to be considered as well. As this review has suggested, the implementation of integrated ORs with centralized data display is not inexpensive. Decisionmakers should carefully evaluate their facility’s needs and long-term goals to determine whether this technology is really needed and, if it is, which integration capabilities are appropriate. A summary table is located below (Table 1).

Table 1, Chapter 16. Summary table

<table>
<thead>
<tr>
<th>Scope of the Problem Targeted by the PSP (Frequency/Severity)</th>
<th>Strength of Evidence for Effectiveness of the PSPs</th>
<th>Evidence or Potential for Harmful Unintended Consequences</th>
<th>Estimate of Cost</th>
<th>Implementation Issues: How Much do We Know?/How Hard Is it?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common/Low-to-high</td>
<td>Low</td>
<td>Negligible</td>
<td>Moderate</td>
<td>Moderate/Moderate</td>
</tr>
</tbody>
</table>

References


