The Computerworld Honors Program

CASE STUDY

ORGANIZATION:

Duke University Health System

PROJECT NAME:

ORview Perioperative System

LOCATION:
Durham, North Carolina, United States

YEAR:
2006

STATUS:
Laureate

CATEGORY:
Medicine

NOMINATING COMPANY:
IBM Corporation

Summary

ORview is a web portal that provides integrated real-time patient data and follows the patients as they move through the entire perioperative process. Much of this information is collected by other point-of-care systems. ORview's originality is in combining the data from multiple systems into new functions that together provide a unique navigational platform and highly comprehensive Information Technology (IT) infrastructure for all types of providers and staff, facilitating considerable operational, clinical and patient safety rewards.

Introductory Overview

Hospitals in the US typically earn between 25 – 50% of their revenue from surgery. The perioperative area presents unique IT challenges besides being financially important. Optimal operating room utilization depends on the efficient matching of patients to resources as they flow through this costly area. Resources such as surgeons, anesthesiologists, nurses, medical equipment and surgical materials are organized by surgical scheduling and materials management systems linked to perpetual inventories that have much in common to the just-in-time management of a car assembly line. Running in parallel to this logistical exercise are systems that providers use in this busy area to document clinical care.

The acuity and invasiveness of operating room care make this is also an area with great potential for medical error. In the Institute of Medicine's 1999 report "To Err is Human", surgical errors accounted for 7% of the total, with wrong-side, wrong-organ errors and wound infections caused by missed antibiotics alarmingly common. In addition, anesthesia and pain medication administration account for a significant percentage of medication errors. Medication errors account for almost 50% of all medical errors.

Despite the potential for improved efficiencies and quality of care, a relative lack of emphasis for fully integrated perioperative IT solutions pervades the healthcare IT industry. These systems have not been one of the leading products in vendor portfolios or on forefront of Chief Information Officer awareness, falling some way behind systems for Picture Archiving and Communication Systems (PACS), pharmacy, intensive care, radiology, labs and hospital finan-

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cial systems. It is surprising that most Electronic Health Record designs do not even mention perioperative needs at all! This may be partly because the challenges of implementing these systems to their fullest potential are great –very few centers have fully integrated computerization of these areas.

In the absence of commercial systems, most hospitals, particularly academic teaching centers like Duke University Hospital, have developed their perioperative IT infrastructure by the steady accretion of best-of-breed and homegrown systems loosely linked together by interfaces. There is very little true client or database integration, sometimes even within the clinical application suites of the major vendors. This is certainly the case in the perioperative area at Duke, which has established implementations of a surgical scheduling, anesthesia and nursing clinical documentation systems from different vendors. Alongside these perioperative systems is a legacy, mainframe-based Hospital Information System (HIS), a clinic scheduling and billing system and a labs system. All these exchange data by interfaces and most contribute text documents into a Common Data Repository (CDR), which has become the de facto longitudinal medical record.

However, integration by messaging between systems is typically very limited, allowing the pre-population of existing data fields from one system with those from another. This exchange enforces data consistency and saves time, but the overall benefit to the user is the sum of the two exchanging systems, not any new functionality in either system.

ORview is a project at Duke to develop a robust and extensible middleware platform that leverages the data collected by clinical systems in the perioperative area to perform new functions that the individual systems could not do on their own. In doing so, ORview has increased the lifespan of Duke's existing clinical systems, enabled process and business continuity by sheltering them from vendor induced change and kept users happy by allowing the best-of-breed selection of products to continue at a time when "integrated" systems often force functional compromises. By drawing on the data from multiple systems, ORview's unique perspective has redefined the concept of the medical record as a mosaic of data collected from multiple systems and customized to the requirements of the individual user.

In 2001 ORview started with the goal of creating a web application to display anesthesia clinical documents using data collected at the point of care by providers in another information system. With knowledge of the database of this system and with suitable security, ORview was able to present the same data in near real time on the Internet. It rapidly became apparent that merely projecting this information over the web had considerable value for the institution. Instead of looking up anesthesia records from a static workstation in the operating room, providers could search for past records from any Internet browser. Charge capture clerks in offices on the other side of town began to use ORview to manage billing denials and ORview became the ubiquitous way of looking up the old records of difficult cases, improving patient safety.

From these beginnings, ORview grew to incorporate a collection of features that would now be termed a clinical internet "portal". As well as providing the mandatory security features of data encryption, user authentication and user audit, ORview provided a registration module, user management, a user rights mechanism, application logging, a diagnostic dashboard, a standard look-and-feel and a modular architecture geared for expansion. A significant achievement of ORview was to combine data from multiple clinical databases into unique features available to the user in near real-time. For example, operating room scheduling data from one system was combined at the with provider information and case status data from another to produce live

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"airport monitor" Big Screens of a day's cases showing the real time status of cases and the current providers in each room.

In order to completely cover the full span of perioperative informatics, ORview expanded its functionality into areas that were not included at all in the commercial systems. Web clients were written to collect this data in ORview's own database. For example, a simple alerting mechanism for high risk patients was enabled by providers entering the alert data into an ORview web-client in the preoperative screening clinic. When patients came to the OR, the presence of an alert was marked with a flashing 'alert' label next to the patient's case on the Big Screens. A representation of the same data allowed the Big Screen views to be seen in any Browser, and as hyperlinks, the alert labels could be linked to the alert message itself.

This collection of features has earned ORview the term "enterprise middleware" at Duke.

Benefits

ORview was designed to benefit the clinical, research and administrative users of perioperative information at Duke University Hospital. User groups include Anesthesiologists, Surgeons, resident staff, OR administrators, perioperative nursing staff, ward nurses, the preoperative screening unit, charge capture staff and research staff to name a few.

Several of ORview's functions benefit patient safety in unique ways:

•A preoperative check list is shown on the Big Screens as go/no go icons.

•The ubiquitous availability of old anesthesia records and preoperative assessments on the web has made lost records a thing of the past. A past anesthesia record is the single most important piece of information to help with a difficult case.

•The availability of broadcast and emailed high –risk alerts to providers.

•The collection of outcomes and patient satisfaction data by Wi-Fi–enabled Personal Digital Assistant (PDA) devices at the bedside.

Figure 1 shows a bank of Big Screens in the preoperative holding area.

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More unique ORview functions are available to administrators:

•ORview has a hardware innovation – banks of large LCD screens arranged like "airport monitors" provide a highly cost effective, web based solution for operating room management. (see figure 1)

•A wireless messaging system for mobile PDA devices that allows administrators to fold delay, room change, time change and general administrative messages in real time onto the Big Screens for all to see.

•The same messaging function allows the hospital bed control administrators to see and respond to bed request messages sent from the recovery area. Their responses are folded onto a different Big Screen tailored for their area. Such bed control management has cut an average of 10 minutes per case in the transport process from the recovery area to the ward.

•ORview's portal provides a secure area for administrators to access a range of web-based reports, from infection control reports to documentation compliance reports. Many of these span multiple databases.

•ORview made real –time data on operating room drug usage drugs available to the hospital pharmacy. This has transformed the processes of the operating room pharmacy, which no longer issues cassettes of drugs for each case. Now Duke allows the use of "open shelf" restocking of a drug tray in each operating room for all but controlled drugs, since drug use is readily accountable. This has made medications available in a more timely manner for patients, and prevented the need for more expensive automated medication stocking systems.

Clinical users, patients and others also benefit uniquely from ORview:

•Clinical providers have personalized views of their patient's data. They can see a schedule of their cases from home the night before, and look up preoperative and old records on those patients. This functionality is also available on Wi-Fi enabled PDAs.

•ORview accumulates a "logbook" of cases for all providers, with specialized versions for staff in training, like anesthesia residents.

•ORview contains a standalone web client that provides a comprehensive preoperative anesthesia assessment and surgical history and physical examination. Central to this application are linkages to other hospital systems for appointments, allergies and medication lists. This mobile application also has an extensive coding underpinning, being able to rapidly present massive lists by type –ahead search in a pure web client. The entire ICD9 diagnosis, CPT and First Databank Medications lists are available to practitioners in real time by type-ahead search. This feature has enabled a potent mix of usability and coding that allows structured data to be collected for quality and research initiatives.

•ORview also contains a standalone web client designed to be used on Wi-Fi enabled PDAs for collecting postoperative information from the patient at the bedside. This is in fact a generic questionnaire mini-portal that can present an infinite variety of question sets and collect their responses. At Duke it is used for the required 48hour postoperative visit, and there are plans to tailor its use for the collection of case data from clinical trials. Combined with the preoperative assessment, scheduling data and intraoperative point-of-care data, this post-operative visit data rounds out a comprehensive data picture of the entire perioperative encounter.

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•The Big Screens allow providers to rapidly find the patients they are involved with in the OR, preoperative and recovery areas.

•ORview enables near real-time remote monitoring of anesthesia cases from any Internet browser.

•The ORview messaging system enables a communication link between perioperative nurses and the personnel in the patient and relatives waiting areas. Information about loved ones is timely and requires no phone calls. This also is in use by ward nurses, who are able to track the status of patients during their intra-operative event, and keep relatives informed.

•Researchers and pathology staff use ORview to time their interventions in the OR for collecting specimens.

•Researchers use ORview for answering detailed questions. Underlying the graphics in ORview are easily downloaded discrete data points. Lawyers have used the ORview record to capture a concise picture of the entire case.

Can the ORview technology be generalized and used outside the Duke perioperative environment? ORview's middleware is already working in a multi-entity environment at Duke, working in the three physically separate operating room environments that comprise Duke University Hospital. To function outside the perioperative arena, ORview would need to work with a collection of different vendor and hospital information systems by writing "plugins" to their systems. By translating the data from multiple databases into common or standard objects in ORview, and then presenting that data in a single view on the web, ORview provides an alternative approach to achieving interoperability. For example, it is perfectly possible for ORview to read the data from various medical specialty clinics housed in multiple IT systems, present it in a common format over the web and become the "Clinicview". Users would see a standard record, no matter which vendor system was used to collect the data at the point of care.

The Importance of Technology

The goal of the ORview project was to use novel IT approaches to provide functionality not present in the existing commercial or homegrown IT solutions at Duke. ORview has both software and hardware components integrated together to do this.

The ORview software is a web application written in the Java programming language using the open source STRUTS web application framework. The choice of open source software freely available on the web, together with the liberal use of programming forums and websites, enabled ORview's rapid development. Components such as calendar controls, the NetBeans development environment, the Log4J logging program and the CVS versioning system were incorporated into ORview directly from open source initiatives.

Apart from its software ORview uses the following technology:

•Wi-Fi enabled PDAs are used to record surgical and anesthesia outcomes at the bedside. Collected data is posted directly to the ORview database and also to the Common Data Repository using a standard messaging system.

•ORview Big Screens use multi-head video cards with a bank of 21" panels in portrait mode. By spreading a single Internet browser page across the bank the effect is to produce a highly cost-

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effective, auto-refreshing, thin client, continuous view of Operating Room status for over 100 cases simultaneously.

A feature not available to commercial systems is the IT "laboratory" at Duke – the constant stream of real patient data being generated by our point-of-care clinical systems makes it possible to rapidly develop test environments that accelerated the creation of ORview components.

Originality

Several aspects of ORview were entirely original and never performed before. These included:-

•The visualization of anesthesia records on the Internet.

•The ability to monitor live anesthesia cases in near real- time from any Internet browser.

•The visualization of anesthesia records and personal operating room schedules on a mobile device, with real-time monitoring of cases.

•Use of a web browser to represent a live operating room schedule spread over multiple Big Screens like an airport monitor.

•The creation of a high-risk patient alerting mechanism folded into Big Screen views of the operating room schedule, or emailed directly to providers.

•The creation of a web-based preoperative checklist folded into Big Screen views.

•The collection of post-operative data using Wi-Fi-enabled PDA devices.

•The use of a generic messaging system and PDA devices to post OR schedule changes directly to the Big Screens.

•The use of middleware to combine data from multiple systems in the perioperative environment.

•The posting of bed requests and responses from bed control in the recovery area using an Internet messaging system and ORview's Big Screens.

•The use of AJAX technology to enable item selection in massive lists of drugs and coding systems using type-ahead search in ORview's preoperative assessment.

•The use of a key-based user rights mechanism to manage the registration of users and assign their exact user rights over the Internet.

•The use of encryption to de-identify patient identifiers in hyperlinks.

•The ability to dynamically de-identify patient data from webpages for users with "demonstration" rights so they can continue to work with, train on and demonstrate live Duke perioperative data.

Success

ORview is fully operational on a 365/24/7 basis at Duke. It has to be, as the Big Screens, using nothing more than an Internet browser, automatically refresh with new data every 3 minutes. Since there are 6 continuously operational banks of Big Screens showing the status of active cases in the perioperative area, this is a considerable test of the overall robustness of the system.

THE COMPUTERWORLD HONORS PROGRAM

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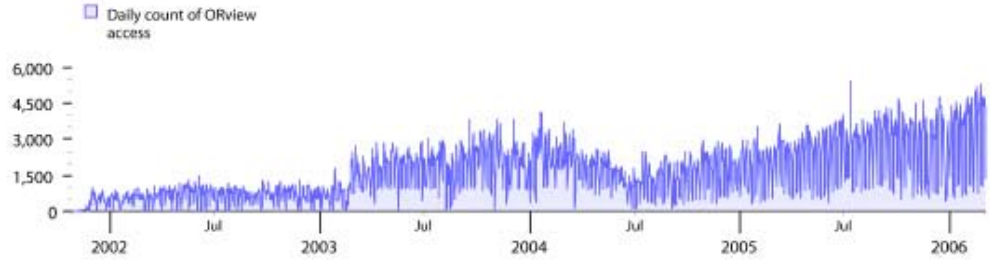
The number of daily uses are shown below in Figure 2.



ORview is now used over 5000 times by over 160 users in any one day (more than 1.5 million accesses per year). It has a total user base of about 700 active users. At peak rates in the morning it is accessed about 500 times an hour. To put this in perspective, about 140 surgical cases are performed each day in 45 operating rooms at Duke.

These user metrics, taken directly from ORview's audit functionality, far exceed the original design goal of making anesthesia records available on the Internet. To the typical user such as an anesthesiologist, the following illustrates a common usage pattern:-

1)Operating room cases are assigned to anesthesia staff in the perioperative scheduling system at 3pm the day before. At this point they become known to ORview.

2)Using Internet Explorer, our user logs into ORview at 7pm from home to look at his next day's cases. He navigates to ORview's "my cases" section and is able to see the detail of the cases assigned to him. Some cases have been to Duke before, and he is able to use hyperlinks to view those old records. All his cases have been to the preoperative assessment clinic, so he scrolls through the preoperative assessments of each of his cases thinking of his anesthesia plan for each.

3)Included in the "my cases" section are the few remaining patients from his current day's work as they recover. He is able to directly open their records and check up on their progress in real-time.

4)At 8pm he is called by an anesthesia resident, who has also used ORview to look at her next day's work, and between them they formulate an individual plan for each patient. They discuss the "alert" message associated with one high risk patient (for a difficult intubation) and instructions are given to the resident.

5)Arriving in the OR at 6:45 the next morning, our user walks directly to one of the banks of ORview Big Screens in the preoperative holding area and checks the location of his patient among the 35 or so cases waiting to enter the OR. He then walks right up to the bedside and greets the patient remembering all the case details from his study the night before.

6)Our anesthesiologist and resident user are prevented from taking the patient back to the OR by the vigilant preop holding nurse, who noticed that the surgeon has yet to mark the patient's operative site. The icon on the Big Screen indicates there is in a "no go" status on this case until this is done. Because of this, the OR front desk posts a delay message into ORview, and amends the start time of the case, with both these changes reflecting in the Big Screen.

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7)Once safely asleep in the OR, our patient is under the care of the resident. The anesthesiologist opens up his PDA and sees that his next patient has not yet arrived, goes to his office to read email and simultaneously opens up the case in ORview, which he continues to remotely monitor. Vitals signs and all interventions by the resident update automatically.

8)In the background, a clerk in the relative's waiting area uses their continuous ORview access to see the transition of the patient from the preop holding area to the operating room, and informs relatives that their loved one is asleep with the operation underway.

9) In recovery, the nurse in charge uses her bank of ORview Big Screens to check on the status of cases as they unfold in the operating room. Bed Control staff, down in the basement of the hospital, are doing the same, anticipating a "crunch" in available beds later in the day.

10)The anesthesiologist uses his PDA to anticipate the end of the case and uses his PDA to arrive just in time to wake the patient up. Since he can be supervising 4 operating rooms simultaneously, getting to the important stages of each cases is a considerable logistical exercise and he is thankful for the assistance of the constantly updated personal case view in his PDA.

11)Once in recovery, the bedside nurse enters an event in her point of care system indicating the need for an intermediate level step-down bed on the ward. This is seen simultaneously seen by administrators in bed control, who respond with an acknowledgement. When they know the exact room assignment, they again send a message, which is picked up by recovery and transporter staff using the bank of Big Screens there. It is also seen in the patient waiting area, and relatives are directed to that room to wait for their loved one.

Below are a series of quotes from ORview users:

"ORview offers many advantages to me. As a clinician, it is invaluable to be able to review prior anesthetic records day or night, without needing to retrieve medical records. This facilitates better and safer patient care.

As a residency program director, ORview and its caselog and postop programs are useful to help me review resident experience, ensure that each resident is achieving his or her milestones, and to assess compliance with various program requirements. The residents appreciate being able to enter their data on the work stations during the cases, and this yields more accurate reports.

Catherine K. Lineberger, M.D.
Associate Professor of Anesthesiology
Residency Program Director

"ORview provides instant access to prior anesthesia records, eliminating the angst of missing patient charts and inability to find crucial clinical information. This is a huge step forward in patient safety".

Richard Moon, MD
Anesthesiologist.

"Iain, I found it most beneficial when I had a family member having surgery and post recovery. The staff in the family waiting area had their information readily available."

Larry A Dowell
Patient family member

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"ORview is revolutionary! ORview does it all in a single program that I can access on my PDA. Pre-op it allows me to view my schedule for the next day in detail. On the day of surgery, I can follow my patients' progress and anticipate critical events that require my personal attention. When coordinating the flow of patients through the ORs, ORview provides real time data on the status of each OR and allows for more efficient management and patient care. If that is not enough, ORview also provides a template for documenting postoperative evaluation in a manner that permits data collection with the ultimate goal of improving anesthetic care."

Cathleen Peterson-Lyne, MD.
Anesthesiologist

"OR View has been very helpful on the 2nd floor to help communicate and plan for patient flow during the day. Early AM, the charge nurse and bedflow manager can assess the need for bed availability with the planned OR schedule. The charge nurse can look at the OR schedule, calculate when the patient is due in PACU and then to their floor. With this information they can work with the ICU to prioritize the patient movement and the other floors to facilitate patient transfers and free up the stepdown beds. If the patient doesn't arrive when expected, the charge nurse can look in OR View and see the progress of the patient or if there has been a change of plans. The care nurses can also start gathering information to speed up the report process."

Sylvia C. Pickett, RN
Nurse Manager - Educator
Medical Surgical and Critical Care Services

"To have ORView at my hand at the bedside is the most efficient use of my time when needing to find all of the patients history and most current info quickly."

Yvonne Overcast, CRNA,MS
Department of Anesthesiology

"ORview has proved to be an valuable tool in our arsenal for appealing insurance claim denials. The Real Time access allows us to get immediate feedback and documentation to support additional add on procedures such as cath placements, Swan-Ganz catheters and arterial lines. In addition, the injections for post operative pain management, often inappropriately bundled by most managed care carriers, clearly document these services as separate procedures. Because the reports are only a point and click away, we have been able to file our appeals in a timely manner and successfully seek the reimbursement for our providers. Our turn around time on appeals is so much faster than before, it is truly amazing."

Thomas M. Beach, CPC
Data Quality Coordinator, Coding and Billing
Duke University Health System Revenue Management
Reimbursement and Coding Services

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"OR View is an innovated way to coordinate and manage surgical beds throughout the shift. It is easy to learn and use. It has cut down the amount of phone calls considerably. It gives a real time snapshot of the patient in the OR and PACU. This allows Bed Control to plan for an upgrade to a step-down bed if necessary or any special needs required. We love it."

Marie Hale, RN
Clinical Operations Director
Duke Transfer Center
Bed Control

"OR view has helped me by diminishing the large amount of telephone calls made per patient. Also, it helps me in planning out my placements by having the ability to track the patients through the entire OR process. On occasion, I've also used it to get additional information on the patient's condition when I need to off service the patient. All in all OR view is a wonderful tool in bed control."
Daniela Lopez.
Bed Control

Difficulty

Sometimes users need a lot of convincing that radical new ways of performing their work are worth exploring. When ORview started as the personal project of a single physician at Duke, there was no planned implementation schedule or even demand for it. As an alternative view of core data that could be seen elsewhere, ORview was not initially essential. When new functionality was made available, it was adopted by personal recommendation, rather than pushed to users through any planned roll-out. However, from the very beginning ORview radically changed the way providers viewed anesthesia records by making them available on the Internet, so the adoption of this feature was very fast. Some of the changes have been very obvious to staff – its difficult not to notice a bank of Big Screens, so adoption of these has also been fast and demand by administrators.

In other places this has not been the case. Operating room management processes are very manual, entrenched and technology averse, so convincing users of the benefits of preoperative checklists, PDAs and messaging has been harder than anticipated. Many of these advances have simply been too radical a change in practice for users to understand the benefit. The approach has been "build it and they will come". Eventually they do. For example, two years after a generic messaging system was introduced, the operating room front desk staff started to post messages of delays and room changes to the Big Screens. The front desk staff were convinced of the benefit only after they saw the recovery nurses use the same messaging system for Bed Control purposes.

Adoption has been much easier where ORview's features were commissioned, such as by pharmacy to provide a web view of pharmacy billing data taken from the OR. In 2004 a new group was formed to develop perioperative IT solutions and ORview was made its central development platform. Having reached a tipping point of acceptance, and after they acquired the necessary skills, the new group has been able to create a string of commissioned ORview modules such as the Post Operative Visit, the resident Logbook and most recently a web-based Preoperative Assessment. The new IT group has the resources to orchestrate a well-planned roll-out, and support the new feature, for a large group of users. Even so, these roll-outs have not been easy.

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For example, the initial batch of Wi-Fi PDA's lost their battery power and configurations very easily, completely undermining confidence in this technology for large cadre of resident and nursing users. Fortunately, and with a great deal of support, they have persisted and now collect data on over 50 inpatients/day using PDA's. Another example is the preoperative assessment where ORview has inserted an electronic process in the busiest clinic in the hospital, with up to 100 patient visits/day. Only careful and cautious co-development with the clinic users, together with a resource study to examine the impact of the new tool on clinic processes, has made this successful.