Implementation and Use of a Patient Data Management System in the Intensive Care Unit: A Two-Year Experience

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Abstract

Patient Data Management Systems (PDMS) have traditionally formed the amalgam between the patient monitoring system and hospital information system. The Thoraxcenter set out to replace a mixture of paper-based registrations and in-house developed applications with a new digital PDMS. The PDMS Innovian was selected in 2003, was configured in 2004 and has been in use since 2005.

1.   Introduction

Patient Data Management Systems (PDMS) [1, 2, 3] have traditionally formed the amalgam between the patient monitoring system and hospital information system. A PDMS automatically collects and stores vital parameters from the patient monitor, provides a digital patient chart and is often considered as the primary system for nurses and physicians in the intensive care setting.

The Thoraxcenter, a combination of the cardiology and thoracic surgery departments of the Erasmus MC, set out to replace a mixture of paper-based registrations and in-house developed applications for the intensive care units with a new digital information system. In this article we describe our experiences with the requirements, implementation and operational use of new PDMS in the Thoraxcenter.

2.   Requirements

The requirements of a new PDMS have been based on list that was defined for the selection of our integrated patient monitoring system in 1996. The key points for the monitoring system requirements were a consistent user interface, continuity of data (data "travels" with the patient), integration with existing information systems and compliance to open standards, such as TCP/IP.

First, the PDMS should be able to work across intensive care units, operating theatres and step down units, while maintaining a single patient record. The patient workflow is often cross-departmental. For example, a patient who

underwent a percutaneous coronary intervention procedure may suffer from complications days later during his recovery at the telemetry step down unit. Thus, continuity of care and availability of data are a vital part in the selection of an information system. A typical data flow of a patient admitted with an acute myocardial infarction is illustrated in Figure 1.
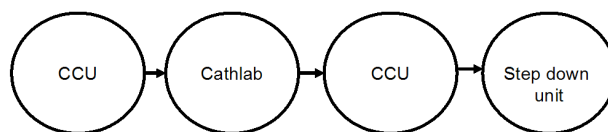

Figure 1. Typical patient flow across care units of a patient with an acute myocardial infarction.

Second, the PDMS should be easy to use and provide a consistent and familiar user interface. In the complex setting of the intensive and coronary care unit, clinicians need to work with a multitude of information systems. A reduction in training time may also reduce medical errors.

Third, the system should be linked and integrated with the various hospital information systems. The central hospital information systems, such as the laboratory system, the medication registration system of the pharmacy department and the electronic patient record system, should not only be linked on a patient identification level, but also with a so-called cursor time. For example, if a physician wants to review an earlier patient stay, the systems should provide the appropriate information of the earlier stay.

Fourth, the system should be modular and extensible. Virtually no commercially available information system can incorporate all wishes from users. Therefore, a new PDMS should be able to accommodate small changes and additions, before a definitive solution is made available by the vendor.

Fifth, the system should use standard ICT solutions. Because a PDMS is an information system, parts of the application and technical support, such as the network infrastruc-

ture and database maintenance, will be handled by the ICT services staff of the institute.

The following requirements were included as well:

- single admit
- customized screens for each care unit
- all monitored vital signs stored and available indefinitely
- combine vital sign information with treatment
- structured notes and transfer/discharge reports
- nursing assessments
- combine vital signs with events and 12 lead ECG
- support for teaching, research and data management

Because of the very specific requirements pertaining to the integration with the patient monitoring and combining waveforms with patient flow sheets, the Innovian system (Draeger Medical Systems, Andover, MA, USA) was selected. Table 1 provides an overview of the main features of this system in the Thoraxcenter. Innovian has not been positioned by Draeger Medical as a PDMS, but rather as an advanced ICT extension of the patient monitoring network. At the time of the selection, important points, such as order communication screens were not available, although the most recent version of Innovian now supports this.

Table 1. Overview of the Innovian system

	Description
Beds	8 intensive coronary intensive care
	10 cardiothoracic intensive care
	4 high care beds
	55 telemetry transmitters on 2 step down
	care units and the heart transplantation unit
Screens	web-based access to:
	flow sheets, fluid in/out,
	laboratory, medication,
	events (including 12-lead ECGs),
	trends (1-minute interval),
	admit/discharge/transfer,
	diagnoses, procedures, and
	risk stratification scores
Reports	discharge, shift and 24-hour reports

3.   Implementation

The implementation of Innovian was carried out by a small, multi-disciplinary team of clinicians and technicians. The ICT group of the Thoraxcenter was responsible for the installation and maintenance of Innovian and dedicated two software engineers and one project leader to the project. The project leader was a single point of contact to the users and had a nursing background as well as ICT experience. The implementation consisted of five parts, which are described in the following paragraphs.

3.1.   System configuration

A new Innovian installation needs customizations on a functional level. Each department has a list of specific requests regarding screen layouts, data entry and data presentation, such as the preference for graphical or tabular representation of vital signs. In order to facilitate these needs, the work flow, documentation and data collection processes on the intensive care units had to be analyzed. In this stage, the project leader used a live system to work with the various users.

Most of the time in this stage was dedicated to the fine tuning of system configuration items, such as screen layouts, and to set up the list of medications and dosages. We worked closely with the pharmacy department and used their reference lists. The screen layouts were configured for each care unit based on staff preferences and specific work flow processes. The total amount of required time to configure Innovian was approximately 10 weeks.

On a technical level, the Innovian system is a single Windows 2003 server and is available on the patient monitoring network and the hospital intranet. Innovian is a web server running Internet Information Services and Microsoft SQL server 2000. Clients need no special configuration. Microsoft Internet Explorer and Sun Java are sufficient. Figure 2 shows the Innovian installation at the Thoraxcenter.

Innovian supports various HL7 interfaces. In the Thoraxcenter, a solicited patient query interface was implemented between Innovian and the hospital information system. Innovian also receives laboratory results from the hospital-wide laboratory system.
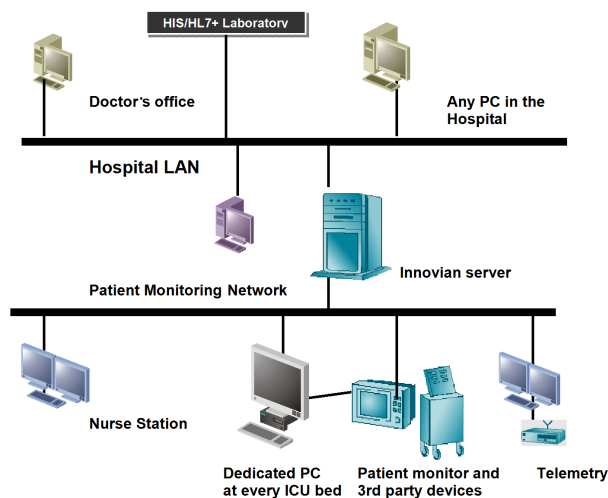

Figure 2. Innovian installation at the Thoraxcenter with network interfaces to the patient monitoring network and the hospital LAN.

3.2. Additional development

There were two areas that were yet not covered in the default setup of Innovian. First, a PDMS such as Innovian requires a continuous uptime and fall back scenarios. Innovian is a web-based system and data is not stored locally. In case of a network failure, data cannot be accessed. For this purpose, Draeger Medical and the Thoraxcenter started a project which replicates the real time PDMS database to several redundant PCs near the care units. In emergency situations, nurses can print the data and revert to paper-based registration.

Second, an important part of the patient work flow consists of information transfer. To support custom discharge and transfer reports for other departments of the Erasmus MC, a web-based report generator "WebCARE" was developed based on the input of the users.

3.3. Training and education

In order to cover a 24-hour service, a group of super users were appointed for each intensive care unit. Most of these super users were involved with the system configuration. The super users were also trained to handle basic user questions and were the primary point of contact outside of the normal office hours in addition to the stand-by service of the Innovian team.

3.4. Acceptation

The configuration, initial testing and custom development activities were carried out in parallel in 2003 and 2004. During this period, a nearly identical production and test environment were defined and implemented. As there was no separate test and acceptation environment, the same hardware was used. Starting from the first Innovian release, every new software release is first evaluated by the super users in the acceptation environment.

3.5. Going "Live"

On February 20th, 2005, Innovian went live with the intensive/coronary and cardiothoracic care units. After careful preparations, the clinicians switched from paper-based to online web-based registration. The high care unit followed a few months later.

4. Run-time experience

The use of the Innovian PDMS improved efficiency by automating and handling admissions, transfers and discharges of monitored patients. Medical and nursing errors were reduced, because flowcharts and medication lists did not need to be copied by hand every day. Other paper-based administrative work was also reduced.

The integration with patient monitoring equipment allowed for a single patient admit procedure. By using Innovian and the integrated HL7 patient query link to the hospital information system, the most up to date patient demographic information can be uploaded to the Draeger patient monitor and nurse station.

Innovian is integrated into the electronic patient record "Elpado" [4] and is available as a web application on any location in the Erasmus MC and at home by using VPN facilities. This availability provides users up-to-date information on treatment, medication, fluid balance, procedures, lab results and new cardiac events (12-lead ECG). An example of a patient with a cardiac arrhythmia during his stay at the coronary care unit is presented in Figure 3.
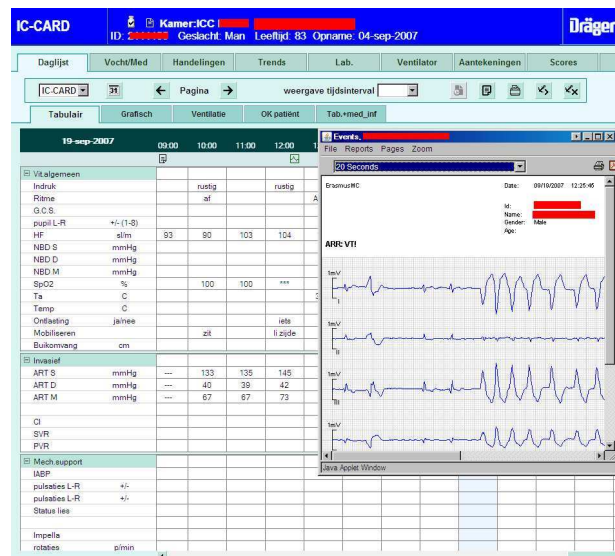

Figure 3. Overview of the Innovian web-based graphical user interface with the tabular flowsheet and an ECG strip.

The learning curve for novice users of the system is short. Because Innovian is based on web technology and is designed to operate with other Draeger equipment, users find the system easy to use. No more than two to three hours of training is usually required. The audit trail functionality also helps in preventing and diagnosing problems.

To facilitate clinical research and data management, SQL queries and data mining tools were developed to provide various types of clinical data, including the length of stay, ventilation days and the number of patients admitted with a specific diagnosis over a period of time.

A number of disadvantages were also found during the day-to-day use of Innovian. First, Innovian is a web-based system. Any problem related to the network may increase application response times. Second, the Thoraxcenter is an

early adopter of Innovian. Bugs may still appear, even after extensive testing by the manufacturer and in the acceptation environment.

5. Discussion and conclusions

The two-year experience with Innovian as a single and central information system for the intensive care and coronary care settings has shown that the system is a success. The system handles all bed sides with patient monitors and has been set up for the telemetry step down units.

A single point of contact with both nursing and IT skills has been instrumental to the success and clinical acceptance of the users. Regular daily informal contacts with the users and formal meetings of an Innovian steering group allow for continuous feedback and may also have contributed to a successful implementation.

5.1. Requirements

During the requirements analysis and final product selection, an important consideration for any organization is if one should choose a single and integrated vendor solution covering multiple care areas or if one should choose the best vendor ("best of breed") for one particular area. For example, our outpatient echocardiography (echo) department has adopted a multiple vendor approach [5]. Part of the success of the echo department is the use of the DICOM standard which is supported by all major echo device manufacturers. Patient monitoring and registration lack such interchange standards. Another reason is that the workflow of the echo department is substantially different from an intensive care setting.

The "best of breed" strategy would encompass specialized PDMSs, such as PICIS (PICIS, Wakefield, MA, USA). This system is currently in use in other wards of the hospital [3]. However, in the requirements and product selection phase, Innovian was preferred because of the tight integration with the patient monitors, the integration of waveforms, including 12-lead ECG and arrhythmia review, and the web-based access.

5.2. Implementation

In the information technology landscape of a large medical center, there is no single system or database with all patient information. Innovian has its own database and in our medical center many other systems with separate databases exist. The most widely used system for patient review and registration is the hospital-wide, component-based electronic patient record system "Elpado". In 2004, Innovian was made available as an embedded component in Elpado as part of the complete cardiology information system initiative [4].

5.3. Run-time experience

Our experience so far with the roll out and maintenance of Innovian is that the system has had a major impact on the daily routine and workflow of the clinicians. Obvious benefits were less paper work and the short learning curve. Super users and a single point of contact for dealing with questions and requests remain essential.

5.4. Future directions

The next step of Innovian in the Thoraxcenter is to roll out the system in the step down units. As the step down units are larger in size and patients are mobile, the implementation plan will also include mobile data entry using wireless technology. In addition, Innovian will be upgraded with new functionalities, including support for care planning, complication registration and user-defined data entry forms.

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