Wireless, Handheld Computers May Aide Resident Workflow and Learning

Frank J. Overdyk, MSEE, MD
Associate Professor of Anesthesiology

Matthew McEvoy, MD
Resident in Anesthesiology

Department of Anesthesia and Perioperative Medicine
Medical University of South Carolina, Charleston, South Carolina

Address correspondence to:
Frank J. Overdyk MSEE, MD
Department of Anesthesia and Perioperative Medicine
525 Children's Hospital (MUSC)
171 Ashley Avenue
Charleston, South Carolina 29425
Email: overdykf@musc.edu
Tel: (843)-792-2322
Fax: (843)-792-2726

Abstract

Background: The newly mandated eighty hour work week for anesthesia residents demands that they make efficient use of their time to accomplish their educational, clinical, and administrative objectives. We set out to help residents with these tasks by developing a point of care handheld computer (HC) system that gives them access to the hospital network and the Internet through a secure, wireless local area network (WLAN) from most perioperative locations.

Methods: Different hardware and software platforms were investigated to meet the capability of the specification above. Five anesthesia residents were asked to evaluate the platform selected through a simple ten-question survey.

Results: The PocketPC operating system and Dell Axim HC with third party encryption and Web browsing software was the best performing platform. Residents unanimously agreed that the system improved their daily workflow efficiency and compliance with administrative requirements. No

electromagnetic interference was noted between the HC or WLAN and medical equipment, cell phones or pagers. One resident saw the Web browsing capability as a potential distraction from patient care.

Conclusion: This system appears to be a valuable tool for resident education, although more rigorous study of its effect on resident vigilance and the safety of patient data are needed.

Keywords: computers, wireless, handheld, resident education, point of care, personal digital assistant (PDA)

Introduction

The learning environment for residents in anesthesia has evolved rapidly over the past few years. The changes in their clinical assignments, administrative responsibilities, and didactic instruction are imposing new demands on their workflow and time in order for them to accomplish their objectives. Since fewer patients are admitted to the hospital prior to surgery, the resident's first encounter with the patient is often in the holding area. The traditional face-to-face history and physical in the patient's room is replaced by a more urgent and often cursory survey of the patient and their paper and electronic medical databases. Ready access to this information at the 'point of care' (POC), including perioperative locations and clinics, is essential[1] and there is anecdotal evidence that it may improve outcomes[2].

In February of 2003, the Accreditation Council on Graduate Medical Education (ACGME) mandated an 80-hour workweek for residents[3], introducing new administrative requirements and logistical challenges for residents. Accurate tracking of their clinical time and cases is essential, and this is best done immediately upon completion of a case and at the end of the workday on the ACGME (case log)[4] and E-val (duty hours log)[5] websites. Other administrative duties include faculty evaluations as mandated by the Residency Review Committee (RRC) and more stringent chart documentation and compliance requirements.

Furthermore, didactic content which in the past was presented in lecture halls and conferences and is considered by the RRC as part of the 80 hour week may now be viewed online in an impressive array of multimedia presentations and formats.

In view of these new requirements and time limitations, we set out to develop a perioperative, wireless local area network (WLAN) using handheld computers (HC's) that would allow residents to optimize their clinical efficiency and facilitate their learning by providing POC access to patient data, Web-based educational content, administrative resources, and email.

Methods

We established two non-negotiable requirements in the specification for this system. The first was portability. The resident should be able to carry the device comfortably in their scrub or coat pocket, thus accessing the desired features at the point of care, which may be the holding area, the operating room, the recovery room, the patient's room or the preoperative clinic. This requirement eliminated tablet computers, larger fixed workstations, and handheld devices with bulky accessory batteries or large wireless network interface cards (NIC's).

The second requirement was wireless access to the Internet and our hospital's Web enabled patient databases, while maintaining compliance with the Health Insurance and Portability Accountability Act (HIPAA). This requirement was intended to give residents the option and the ability to check patient data including lab results, consultation and radiology reports by selecting the icon for our Web enabled Oasis ™ clinical data repository (Denmar Corp, Ottawa, Canada).

This last requirement eliminated several platforms from contention, including all cell phone, 'Web-enabled', devices. Although the Palm operating system, Windows CE, and Pocket PC operating system are the prominent platforms in wireless, handheld connectivity, the Palm and WinCE operating systems were eliminated because they are not compatible with the only third party software available at the

time that supports a HIPAA-compliant wireless security protocol. In our preliminary evaluation, we learned that the Pocket Internet Explorer (PocketIE) browser sold with most HC's is inadequate for Web sites such as the ACGME and E*val™ sites, which contain interactive and multimedia content. These sites, as do the vast majority of current Web sites, use JavaScript or Jscript (an interpretive programming language) and multiple coexisting windows to interact with the visitor. Only HC's and Web browsers capable of interpreting ECMA scripting, the PocketPC equivalent of Jscript, were thus candidates for our platform. We purchased one such third party Web browser, Netfront™ PPC Browser (Access Co.Software), to open multiple windows and run ECMA scripts (JScript 1.5 equiv for HC PPC) on the HC, a requirement for most secure sites.

In addition, we purchased Funk software's Odyssey™ Client to secure the wireless transfer of patient data using HIPAA compliant encryption (128 bit, NDIS5, rolling-key), the only product available at the time for secure wireless connectivity with HC. The wireless network throughout our perioperative environment is implemented using Cisco Systems 352 access points (AP's), antennas in the ceiling that communicate with the network interface card (NIC) in the computer. The NIC in the computer may be either internal to the handheld computer or it can use an external card slot, much like it's predecessor, the MODEM card. The NIC communicates with the AP using the 802.1x security protocol.

Although most people are familiar with wireless computing in their home or at a coffee house using their laptop computer to access a non-secure or simple password protected network, all our on-campus computers require higher-level, secure authentication in order to gain access to our hospital network. Unlike those of laptop computers, not all internal NIC's for HC's are compatible with 802.1x, thus some of the HC's we evaluated used external NIC's. This add further complexity in that they are manufactured by third party vendors and are therefore more likely to have software compatibility problems as well as being bulkier in profile and size (Fig 1).

Because the screen size of the HC is small and the processor slower than in desktop and laptop computers, we modified our internal departmental Website to include a 'HC accessible' page, geared

towards faster downloads and easier viewing on the HC's. We established links to a variety of internal and external sites (Fig 2).

We created a Web-enabled form allowing residents to log adverse events to our quality assurance database at the time and place of the event, as well as document routine quality indices. Residents can order equipment and medications from our anesthesia workroom and pharmacy in the OR using similar Web enabled forms. Residents can update their ACGME case log, log their work hours, evaluate faculty, check assignments and schedules, and manage their email from their HC.

In accordance with our Institutional policy regarding automated patient information and data transmission over the Internet (MUSC-A35), five anesthesia residents in different stages of training evaluated the functionality of the specified system using three different HC's with wi-fi capability (built-in or external wireless NIC cards) and the PocketPC™ operating system that met the specification requirements. The residents evaluated the performance of the wireless HC's through a simple 10-question survey (see Appendix).

Results

We achieved a stable platform with the Dell Axim with its external (Dell) NIC card. The Dell platform provides speed, functionality with PocketPC, ergonomics (size and weight), superior battery life with a backup battery, and it has a modestly sized external NIC that is compatible with HIPAA standards. The Toshiba and iPAQ HC's evaluated were inferior in battery life and form factor. The iPAQ required a bulky third party external NIC card. Other platforms could not meet the HIPAA requirements for secure patient data transmission (Table 1.)

All residents agreed the HC's provided immediate and POC access to Internet based reference material useful for their daily casework. Similarly, all residents agreed the wireless HC's improved their daily workflow by improving communication with faculty, anesthesia techs, and fellow residents.

Furthermore, all residents believed the wireless HC facilitates their compliance with mandatory database requirements (ACGME, E-val, QA) and increases their efficiency by allowing immediate, remote access to schedules, assignments, and e-mail. Four of the five residents believed intraoperative Internet access was not distracting from patient care. All users were pleased with the data transmission rates and found the small display screen acceptable when accessing the sites designed for HC's although extensive scrolling is necessary for other sites. Signal quality was deemed acceptable 80% of the time.

Discussion

When we designed this system, we were confident that the technology had matured to the point that a system with our specifications was within easy reach. This assumption turned out to be flawed, as the pitfalls and limitations shown in the timeline were plenty (Fig 3). Over the 15-month course of the development, we struggled with mismatched hardware and software updates, especially amongst different vendors (Operating system versions, NIC cards, HC's). As soon as a vendor upgraded their product, previous established functionality would fail. We communicated routinely with the vendor engineering departments and we functioned as a de facto beta site for many of their product releases. Our application was one of the more demanding amongst their clients.

Our initial survey suggests our residents believe the HC is an acceptable platform and that modification of our Web pages for HC's, as others have done[6], compensates for its limitations in screen size and display speed. Those residents with prior HC experience were delighted that the WLAN eliminated the inconvenient and often problematic transfer of HC data with desktop databases at the end of each day[7, 8].

This system does not replace the anesthesia information management systems (AIMS) that are slowly penetrating the anesthesia workplace, but offers a subset of their functionality. The device is a 'read-only' device for patient data, as well as an educational and workflow aid. Because we still use a paper

anesthesia record, we did not plan on the device writing patient data to their medical or anesthesia records. We know of no AIMS company that has successfully integrated HC capability but several include HC's in their future development plans.

There remain valid concerns about the security of data on 802.11 WLAN's[9] since they do not have the 'firewall' protection' that a cabled enterprise network provides, which is why we added 128-bit encryption to all our communication. Our residents can update our quality control and outcomes database electronically and in real time, which has increased compliance and decreased response time to adverse events, as previously demonstrated using HC's in a wired network[10]. We have not detected any electromagnetic interference (EMI) between our WLAN AP's and medical devices, cell phones or pagers. Although the power transmitted by our AP's is significant (100mW), the operating frequency of 2.4GHz falls outside that employed by most medical devices and is unlikely to interfere with them unless the AP is in very close proximity[11].

Extensive evaluations of electromagnetic compatibility with medical devices using Bluetooth™ technology, which operates in the same frequency as our WLAN's (but at lower power), found no EMI[12]. Conversely, Gibby et al found negligible degradation in WLAN signal quality when tested for EMI by electrocoagulation units used in the operating room[13]. Although we still have signal reception 'dead zones' in certain perioperative areas, we attribute these to lack of coverage area by our AP's, which typically have a range of 40 meters, and not to EMI from other devices.

A concern of this platform remains that the anesthesia provider will be distracted from patient care by real-time Internet access in the OR. We suspect the form factor of the HC (small screen, limited keyboard) makes this device much less distracting or useful for Internet browsing than the standard screen and full size keyboard of a laptop or larger computer. Loss or theft of the devices remains a liability. Savvy marketing by cell phone companies claiming email and Web browsing capability should not tempt the techno-naïve educator to consider these devices as an option for this platform. These devices currently lack power, speed, memory capacity, screen size, Java script Web interpreters, and encryption capability.

The rapidly expanding pace of handheld technology and our involvement with companies and organizations in the 'debugging' of Web interfaces will make some obstacles we faced obsolete by the time this article is published. Our intention is not to recommend a specific platform but to expose common pitfalls in this type of project and encourage further work, as our residents are very receptive to this technology.

Our initial evaluation of a wireless HC network for the OR suggests this technology has potential to improve the efficiency of residents' daily activity and accelerate their learning, although a more rigorous evaluation that includes the impact on OR vigilance and patient outcome is forthcoming.

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Legends:

Figure 1. Compaq iPaq3900 and Dell Axim Handheld Computers with protruding external Network Interface Cards

Figure 2. Departmental Internal Homepage Handheld Computer Menu

Figure 3. Project timeline and limited problem list

APPENDIX: Resident Survey and Responses

1. Does the HC facilitate your access to patient specific data?	**5 Yes / 0 No**	
2. Does the HC allow you to access reference and educational material at the bedside, which may otherwise not be available?	**5 Yes / 0 No**	
3. Does the HC make it easier for you to communicate with each other, attending and staff through email or Wed enabled forms?	**5 Yes / 0 No**	
4. Does the HC make completing your case log and duty hours easier?	**5 Yes / 0 No**	
5. Does the HC improve your compliance with QA sheets, faculty evaluations, and other administrative requirements?	**5 Yes / 0 No**	
6. Its screen size, scrolling, and keyboard adequate for your daily use?	**5 Yes / 0 No**	
7. How often was wireless signal strength adequate for timely data transfer?	100% **(1)**	80% **(3)**
	60% **(1)**	40% **rarely**
8. Was the transfer speed of data acceptable?	**5 Yes / 0 No**	
9. Did you notice any interference from medical devices?	**5 Yes / 0 No**	
10. Was Web access in the OR a distraction from patient care?	**4 Yes / 1 No**	

Table 1. System Configuration Considerations

Hardware	Operating System	Advantages	Disadvantages	Evaluation?
Palm Tungsten	Palm OS	Popular HC OS	Proprietary OS HIPAA**	Excluded
Blackberry 7100	BlackBerry OS	Multifunctional	Proprietary OS Small screen	Excluded
Handspring Visor	Palm OS	Multifunctional	HIPAA**	Excluded
Toshiba 3740	Pocket PC	Speed/Size	Poor Battery Life	*Evaluated*
Compaq Ipaq3900	Pocket PC	Security Netfront Compatible	Poor Ergonomics	*Evaluated*
Dell Axim X5	Pocket PC	Security Netfront Compatible		*Evaluated*
Sony Clie	Palm OS	Screen resolution	HIPAA**	Excluded

****** incompatible with HIPAA compliant HC software (Odyssey™)

Figure 1: Compaq iPaq3900 and Dell Axim Handheld Computers with protruding external Network Interface Cards

Figure 2: Departmental Internal Homepage Handheld Computer Menu

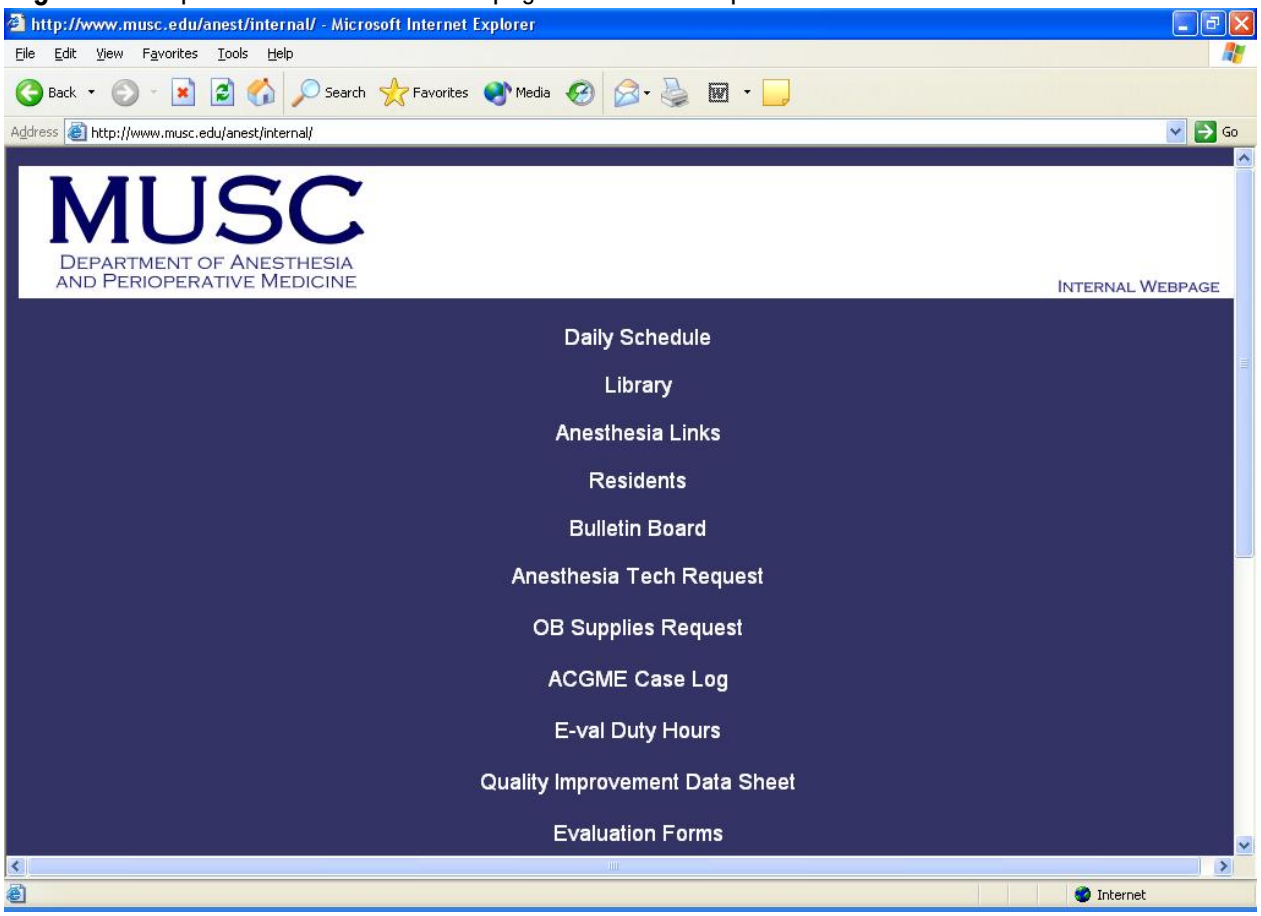

Figure 3: Project timeline and limited problem list