Sleep Diagnosis and Therapy™

Wireless Polysomnography

Like it or not, medicine is going wireless at a breathtaking pace. There has been an evolution from the days when warnings were posted about cell phones interfering with sensitive medical devices to doctors almost effortlessly writing prescriptions via handheld wireless devices. Patient vital signs and movement can be tracked anywhere in the hospital, as can physician encounters in the emergency room. A recent report by Frost and Sullivan projected that the U.S. ambulatory telemetry monitoring market, which was at $330 million in 2003 will reach $637 million by 2011 as many are now recognizing how quickly it leads to improved patient care and staff efficiency.

Sleep labs are also beginning to take advantage of the added simplicity, patient comfort and cost savings associated with wireless technology. Before making purchasing decisions, it is important to understand the past, the present and most importantly future innovations in order to make the right decision about incorporating wireless technology in your lab.

When opening a new sleep lab, the cost of hard-wiring the rooms can be a significant portion of the cost of the installation. The technology manufacturer's installation team must come out, and they must work with the hospital's technical staff often for a day or even two days before systems are up and running. Cabling must be run and tested, and all of this has to be coordinated with the necessary work crews and administrators.

Wireless devices can transmit data through multiple walls without any cables running through ceiling tiles. There are often less components, meaning easier setup and lower risk of individual component failure. Suddenly, setups outside of the lab become more feasible. For example, mobile diagnostic studies in hotels, long term care facilities or nursing homes mean that a comprehensive sleep diagnostic service can come to the patient instead of the patient having to come to the lab for a PSG.

Pushing the need to expand the reaches of the PSG lab could be the increased interest in diagnosing Sleep Disordered Breathing (SDB) in hospital rooms, step down units, or Cardiac Care Unit (CCU). Since SDB is a complicating factor in many surgeries, the ability to conveniently conduct PSG in those settings can improve the peri-operative management of care particularly for bariatric and cardiac surgery patients who have high prevalence of OSA. Another potential application for wireless PSG is to diagnose those inpatients with cardiovascular disease who are also suspected of having OSA. Studies are being conducted to support the theory that patients can recover more quickly from some acute illnesses if their OSA is diagnosed and treated with CPAP while still hospitalized, which only makes sense given the evidence that nasal CPAP improves hypertension[1], Congestive Heart Failure (CHF)[2] status and insulin sensitivity[3].

Hospital networks or intranets, either wired or wireless, are being used to transfer sleep studies from the bedside to the sleep lab. Technicians can monitor and respond to problems, yet the patient is still under the immediate supervision of skilled nurses[4]. But, anyone who has ever lost a connection on a cell phone knows that wireless technology is not yet flawless. And having to phone your mother back to explain you didn't just hang up on her is not nearly as serious as what could happen if a PSG study is interrupted several times through the night. Typically, the amount of PSG data being transmitted is so large that even brief lapses can disrupt acquisition, annoy sleep techs and may affect data interpretation.

Wireless systems work by transmitting data via electromagnetic waves at a defined frequency. Some of the earliest devices used for neurological applications transmitted in the 900 MHz frequency range (part of the unlicensed Industrial Scientific Medical band (ISM)). Many other hospital devices such as ECG telemetry systems are in the 402-405 MHz range. By far, the most commonly used band for both medical and non-medical devices is the 2.4 GHz range (also part of ISM). This is because the technology is readily available as "off-the-shelf" pieces such as wireless network cards that can easily be placed in a PSG acquisition system. The problem with the 2.4 GHz band is that there are so many devices and peripherals operating within that band including Wireless Local Area Network (WLAN), cordless phones, Bluetooth devices, security cameras, Zigbee devices, and even microwave ovens. With so much congestion in this band, the probability of losing data due to radio frequency interference increases. In order to enhance their immunity to interference, most wireless devices operate in a pseudo-random fashion, a strategy known as "hopping". Because the signal is not stationary, there is less chance of it being continually blocked by something else already taking up space in that band.

This approach works well for small and intermittent transmissions, like browsing the internet or writing prescriptions, where any interruptions due to RF interference can be buffered and retransmitted quickly. Sleep studies however, have large data files that are continuously streaming for hours, which make the process of data recovery more difficult if not impossible. One potential way to mitigate this problem is to simultaneously store the PSG data in memory inside the bed-side unit and use the transmitted data only for basic patient status check and to confirm electrode connections. In that case, sleep technicians and doctors can download the data the following day and use the downloaded data set for scoring and interpretation.

Another hurdle facing the implementation of 2.4 GHz wireless technologies in PSG is the underlying data transmission protocol. TCP/IP and other popular IT protocols were not designed for the transmission of sensitive and time critical medical data; these protocols cannot guarantee the reception of patient data in a timely or secured fashion. Protocol improvements to enhance security and Quality of Service are underway, but their ultimate success in PSG remains to be seen.

The 900 MHz and the 2.4 GHz bands are not the only options for future generations of wireless PSG devices. In an effort to avoid disruptions to highly sensitive and sometimes life-critical transmissions within hospitals, in June 2000 the US Federal Communications Commission (FCC) established a set of bands in the 600 and 1400 MHz bands dedicated for hospital medical telemetry. This new guideline is known as Wireless Medical Telemetry System or WMTS. Each device manufacturer will have to register their device on a specific band for each hospital that has their device. A radio frequency coordinator will need to be employed at each hospital whose job is to coordinate registration and implementation of these devices with the American Society for Healthcare Engineering (ASHE), which is the main national governing body. Some hospitals already have RF coordinators and most manufacturers have shifted their telemetry devices into the WMTS frequencies. Adoption of this new standard, however, has been mostly limited to life-critical applications such as cardiac telemetry or vital signs monitoring in the ER. Generally, WMTS performance in those applications is considered an improvement over its predecessor systems, although some technical issues remain such as better immunity to broadband noise or government radars [5]. Whether WMTS will play a role in other applications such as PSG remains an open issue.

Regardless of the underlying wireless technology, it is important to conduct a spectrum survey of the environment before installation and periodically thereafter to look for changes in the spectrum. "Based on our own experience in using wireless devices in hospitals, we are working on software which will continuously look for new interference sources and adapt immediately so that critical data is not lost", says Dave Halley, Senior RF engineer at CleveMed.

If a sleep lab is considering going wireless, it is important that they have each potential vendor in for an actual run through, and preferably allow a 30-day trial at their facility. Some wireless units, for instance Bluetooth devices, have a limited range and may not be suitable for labs with long hallways without added tools. Questions which should be asked of potential vendors include:

1. What frequency range does the system operate in? Can that be modified?
2. How far can the patient be from the monitoring room?
3. How many devices can we have working at once without interference (cross-talk) risk?
4. What is the battery life of the device under continuous use? You need to make sure the device will last at least a full night (wireless technology can consume a lot of power).
5. What happens when there is interference – can the device retransmit data? Can you run a "spectrum sweep" of my environment?
6. How difficult is it to change the operating frequency to move away from interference?
7. What bands does the device cover – can it operate in both WMTS and ISM bands?

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