

Early warning

It's 3am and the emergency room is full of patients. A few are so short of breath, they can barely move. Their bodies and lungs are filled with excess fluid – a common complication of heart failure. It's a terrifying scenario, even for patients who have been through it before. But new research may help find a way to predict these episodes before they reach a critical level.

While it may not make the headline news very often, heart failure is a chronic disease that affects more than 22 million people worldwide – with approximately two million new patients diagnosed each year. In Europe alone, more than 10 million people live with heart failure on a daily basis. And as healthcare advances mean an ever-increasing elderly population, the number of heart failure patients is expected to nearly double in the next 30 years.

Most often caused by coronary artery disease, heart failure is a chronic and progressive disease that stems from the heart's inability to pump enough blood to meet the body's needs. Currently, it's the most common cause for hospitalization for people 65 and older. And patients with heart failure often have trouble leading normal lives due to the debilitating effects of the disease – such as shortness of breath, exhaustion and edema. But healthcare treatments are improving and combined with lifestyle changes like a healthy diet and exercise, some heart failure patients can still live relatively normal lives.

Home health

Home telemonitoring is one healthcare trend that seems to help heart failure patients live more normally by keeping them out of

the hospital – a place nobody wants to go regularly. Home telemonitoring encourages patients to take more responsibility for their own health by monitoring their vital signs and other important elements independently at home. All the measurement data is then transmitted to their healthcare providers for review so treatment adjustments can be made if necessary. Most systems also have an alert feature that can help care providers detect inconsistencies that need follow-up.

Importantly, patients become more involved in their own treatment. "With home telemonitoring, patients seem to feel more responsible for their own health and become more actively involved. It helps patients be more optimistic about their prognosis while, at the same time, being more compliant with medication and treatment," says Patrick Schauer, head of the cardiology department at the University Clinic of Aachen in Germany.

In fact, a recent meta-analysis of 14 heart-failure related medical trials found that telemonitoring reduced all-cause mortality by 20% compared with conventional care. There was also an average 21% reduction in hospital admissions rates for heart failure patients using telemonitoring systems. >





A heart failure patient takes his daily blood pressure measurement with a home telemonitoring system.



Heart rate is measured using ECG textile sensors in the pillow case and bed sheet while the patient is asleep.

Deadly deterioration

But one thing the current home telemonitoring systems cannot yet do is successfully predict decompensation – one of the most serious complications of heart failure. Decompensation is when the progressive deterioration of a patient's heart leads to potentially life-threatening conditions, such as extensive fluid accumulation in the body and lungs. This fluid, primarily salt and water, builds up in various locations and results in weight gain, peripheral swelling and edema. When the fluid infiltrates air spaces within the lungs and reduces the amount of oxygen that can enter the blood, it can be very difficult for patients to breathe – particularly at night when the body is horizontal.

Decompensation can be a terrifying experience for patients both physically and emotionally. In fact, these decompensation events help contribute to the high mortality rate of patients: nearly half of all heart failure patients die within four years of diagnosis, a life expectancy lower than most cancer patients.

Not only does decompensation cause permanent damage to an already-fragile heart, but symptoms usually go unnoticed until the process is well advanced. At that point, hospitalization is often required to stabilize the patient's health. "For heart failure patients, hospitalization is a very stressful experience – physically, mentally and emotionally.


Not to mention the huge costs involved with hospital care, especially in the United States," explains Schauerte. "Often, after a decompensation, patients are in the hospital for 5-10 days. It really takes a toll on them in many ways."

But if decompensation is caught early enough – before it hits the critical stage in which the lungs fill with fluid – doctors can usually treat patients with medication without the need for hospitalization. This saves the patient from the severe psychological and physical trauma of not being able to breathe or move about, as well as the stress and anxiety involved with hospital stays.

Reducing the rate

As the high rate of hospitalizations for heart failure patients shows, decompensation isn't always easy to catch early on. And although home telemonitoring can warn doctors of many different issues that heart failure patients may be dealing with, current systems cannot yet detect potential decompensation.

"Heart failure patients often experience a gradual deterioration in health status over weeks before ultimately requiring hospitalization," notes Sarwat Chaudhry, assistant professor of medicine at Yale University in the US. "A system of frequent monitoring may help clinicians to intervene early and thereby avoid the need for hospitalization."



Philips Research is developing advanced heart failure management techniques intended to do just that: warn of a possible life-threatening decompensation several days in advance. Using highly sensitive textile sensors, these techniques allow heart failure patients to take even more advanced measurements such as breathing patterns, body movement and even electrocardiogram (ECG or EKG) readings at home with the results sent directly to their healthcare providers.

Measurements made easy

One technique is based on an upper-body vest that patients wear for just five minutes a day. Integrated textile electrodes within the vest can take ECG readings during rest as well as during gentle movement – important for getting a complete picture of the patient's health. Normally, patients would need to visit the hospital or a specialist for such measurements but with the vest it can be done quickly by the patient in the comfort of their own home.

The bed-monitoring technique consists of unobtrusive sensors weaved into the pillowcase and at the foot of the bed sheet in such a way that the two electrodes can pick up the subtle electrical impulses of the heart. Another integrated sensor, made from pressure-sensitive material, is located in the middle

Heart healthy

The research into new techniques for detecting decompensation grew out of an initiative called MyHeart, one of the largest European research projects completed in the field of personal healthcare. Partially funded by the European Union, the project brought together more than 30 partners from different areas of expertise including industry, academia, research and medical organizations. Partners came from ten European countries all with the same goal of earlier diagnosis and prevention of cardiovascular disease.



of the bed beneath the mattress cover to detect the patient's movement during sleep. This sensor is also sensitive enough to assess the chest movements associated with breathing and can even detect the ballistic recoil generated by heart-muscle contractions. And while it may sound uncomfortable, the bed sheets are 98% cotton so patients rarely, if ever, notice a difference between these bed sheets and normal ones.

These sensors communicate measurement data wirelessly to a PDA that houses the heart failure management software. After guiding patients through the daily process of taking their weight, blood pressure and ECG measurements, the program then combines this data with information from the bed sensors to assess changes in overall heart function. Measurement data could then be automatically delivered to healthcare providers either through the phone line, as with Philips' current telemonitoring system, or through a broadband connection similar to Philips' Motiva interactive healthcare platform. If the results indicate any potential problems, the doctor may have time to adjust the treatment, hopefully avoiding patient hospitalization.

Worth the wait

One of the key technologies developed by Philips Research relates to the signal-processing algorithms needed to extract ECG data from the electrodes built into the vest and bed sensors. Because the sensors need to be unobtrusive, it's taken years to develop and refine them to be highly sensitive.

But also interesting is the highly specific alert system that comes with the new features, which have been designed to give better warnings regarding potential patient issues. "Sometimes it's hard for care providers to tell when a patient really has a problem and needs quick follow-up or if it's just a low-risk alert," explains Richard Willmann, from the heart failure project team at Philips Research. "With the new techniques, the warning system relies on multiple parameters that are easier to adjust and can be tailored to specific patients, hopefully making it easier for doctors and nurses to identify serious patient issues more quickly."

Currently, the new techniques are being tested and refined in an observational telemonitoring study conducted with six European university clinics, with results expected in mid-2010. So while it may be a few years before most heart failure patients have the chance to use the new technology, the possibility of an earlier warning system when decompensation strikes may well be worth the wait. 