Achieving Clinical Quality from Wireless Sensors

P. Charlton* and T. Bonnici*, D.A. Clifton, L. Tarassenko, P.J. Watkinson, R. Beale

***Abstract*— Wireless sensors may aid detection of clinical deteriorations in hospital patients. Potential routes for translating this technology into changed patient outcomes are discussed, whilst acknowledging the challenges associated with its integration into clinical practice. Results from a clinical trial investigating the feasibility and efficacy of continuous inpatient monitoring using wireless sensors will be presented.**

I. The Role of Wireless Sensors in Hospital

Clinical deterioration of hospital patients must be recognised early to maintain patient safety and minimise treatment costs. The current standard of care for patients on an acute hospital ward is to have vital signs (physiological parameters) measured manually every 4-6 hours. This facilitates detection of the physiological changes which accompany clinical deterioration and, therefore, timely intervention. At present, continuous monitoring is only available in a few high acuity areas and is typically carried out using fixed monitors, which restrict patients' mobility, thereby hindering their progress towards full recovery.

Wireless sensors can provide continuous automated measurement of all five routinely monitored vital signs: heart rate, blood pressure, respiratory rate, temperature and arterial oxygen saturation [1] without hindering mobilisation. Furthermore, sophisticated risk prediction algorithms can be used to identify the more subtle early signs of deteriorations [2]. However, there are many design challenges which must be overcome for wireless sensors to gain widespread clinical acceptance [3]. Leaving these aside, greater utilisation of wireless sensors in routine hospital care may facilitate earlier recognition of deteriorations whilst reducing nursing workload and allowing patients to mobilise freely.

II. Future Research

The key question is whether routine, hospital-wide continuous wireless monitoring confers a clinically meaningful advantage over standard intermittent monitoring. Evidence for the benefit of continuous monitoring is lacking [4] and current systems suffer from frequent false alerts – "alarm noise" – which may paradoxically result in worse patient care. If multi-parameter risk prediction algorithms were used to generate smart alarms, then the benefits of wireless sensors may become apparent. Such algorithms could exploit the following advantages of continuous data:

1. The increased frequency of measurement could provide earlier detection of changes in physiology.
2. Patient-specific models of baseline physiology could be constructed quickly and adaptively during monitoring.
3. Deranged physiology could be contextualised according to whether previous derangements led to deterioration.
4. The accuracy of measurements could be ascertained from the stream of continuous data, *e.g.* using Kalman filters.
5. Characteristic physiological trajectories (state as a function of time) could be identified from continuous data.
6. Physiological variability, representing maintenance of homeostasis, could be quantified from continuous data.

III. Clinical Trial Results

In this presentation we will present results from a widespread clinical trial using wireless sensors on hospital wards. We have acquired data from wireless sensors worn by 225 patients post-cardiac surgery (National Clinical Trial 01549717), alongside expert-annotated deteriorations. The efficacy of the wireless sensors will be quantified using:

A. The proportion of physiological derangements detected by wireless sensors over an hour before standard monitoring.

The feasibility of continuous monitoring using wireless sensors will be quantified using the endpoints:

B. The proportion of patient stay for which good quality continuous data was captured;
C. The frequency of non-critical alerts requiring a response.

This dataset will facilitate design of risk prediction algorithms, and subsequent assessment of the potential benefits of wireless sensors.

* P. Charlton and T. Bonnici contributed equally to this work.

This research was supported by the EPSRC [Grant EP/F058845/1], the National Institute for Health Research (NIHR) comprehensive Biomedical Research Centre at Guy's & St Thomas' NHS Foundation Trust, and the NIHR Oxford Biomedical Research Centre Programme. The views expressed are those of the authors and not necessarily those of the EPSRC, the NHS, the NIHR or the Department of Health.

P. Charlton (e-mail: peter.charlton @ gstt.nhs.uk), T. Bonnici and R. Beale are with the Division of Asthma, Allergy and Lung Biology, King's College London (KCL), London SE1 9RT, UK; P. Charlton is also with the Department of Imaging Sciences and Biomedical Engineering, KCL, London SE1 7EH, UK.

D.A. Clifton and L. Tarassenko are with the Institute of Biomedical Engineering, University of Oxford, Oxford OX3 9DU, UK.

P.J. Watkinson is with the Oxford Biomedical Research Centre, Oxford, UK.

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