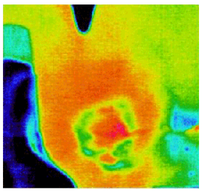
Wounds International Vol 1 | Issue 1 ©Wounds International 2009

Innovations in pressure ulcer prevention and management: key initiatives introduced in Japan

09/11/09 | Pressure ulcers | Practice development | Hiromi Sanada, Junko Sugama, Gojiro Nakagami



This paper is one of a series of three examining innovations in pressure ulcer prevention and management. Among a number of fascinating innovations, the problem of how to prevent pressure damage in patients with an extreme bony prominence is discussed.

Key innovations in Japan

1. Adoption of routine ultrasound use to identify deep tissue damage.
2. Implementation of temperature measurement (thermography) as a tool to predict delayed wound healing.
3. Development of a special support surface for patients in Japan because of the problem of extreme bony prominence.
4. Development of a hand-held measuring sensor device to accurately determine the interface pressure between the mattress and patient. This can be used to check whether pressure-relieving interventions are being used effectively.
5. Involvement by the Japanese government to enforce regulation specifying that a penalty fee must be paid by hospitals where there is an inappropriate pressure ulcer management system in place.
6. Introduction of a government reimbursement system in Japan involving the use of specially trained nurses in pressure ulcer prevention and management.

INTRODUCTION

In Japan, research and development initiatives in pressure ulcer management and prevention are conducted by professionals from many disciplines. These include nurses, physicians, rehabilitation therapists and researchers from universities and industry. Their continuing efforts have dramatically improved the outcome and quality of life for many patients.

Three key innovations have arisen from work undertaken in Japan:

- A new management strategy for identifying pressure ulcer deterioration by using ultrasound
- The use of thermography to identify wounds at risk of delayed healing
- The development of a hand-held pressure sensor to accurately determine interface pressure and the effectiveness of interventions.

These technology-based wound care devices have changed practice and helped promote a better understanding of the processes and progression of deep tissue injury and prediction of non-wound healing.

In addition, the development of a specific pressure-reducing mattress for managing patients with extremely bony prominences and a major new drive to improve pressure ulcer prevention using a financial incentive will be discussed.

KEY INNOVATIONS IN JAPAN

Early recognition of deep tissue changes using ultrasound

Aoi *et al* (2009) [1] and Yabunaka *et al* (2009) [2] described the chronological changes seen in deep tissue that are linked to pressure damage and deteriorate to become deep pressure ulcers (Stages 3 and 4 using the National Pressure Ulcer Advisory Panel staging system) [3]. This was demonstrated using10MHz ultrasound. The abnormal presentation of deep tissues seen in pressure ulcers were as follows:

- **Unclear layer structure**. In normal skin tissue, the subcutaneous fat between the superficial fascia and deep fascia is seen as a series of clearly defined layers using ultrasound [2]. We found that, in patients whose areas of pressure damage were deteriorating, the separate layers of the skin structure usually visible were difficult to distinguish [2].
- **Hypoechoic lesion.** The presence of a small lesion containing fluid, such as seroma or haematoma, was often seen in the deep tissue.
- **Discontinuous fascia.** This indicates that the deep or superficial fascia has been damaged or ruptured.

- **Heterogeneous hypoechoic area.** This appears as a round area with non-uniform internal echo within the hypoechoic area, indicating deep tissue necrosis.

These abnormal presentations seen on ultrasound were also accompanied by subcutaneous tissue damage indicated by the presence of inflammatory oedema with increased interstitial fluid.

Pressure ulcers with these manifestations, especially with discontinuous fascia and tended to deteriorate to a severe stage. In 12 cases assessed by ultrasound, 86% with unclear layers and hypoechoic lesions, and 100% of patients with discontinuous fascia and a heterogeneous hypoechoic area, progressed to deeper tissue damage and a more severe grade of ulcer, respectively. This stresses the need for appropriate intervention with pressure redistribution and suitable dressings.

Early recognition of potential wound infection using thermography
We considered that delayed wound healing can be caused by prolonged inflammation that cannot be identified in the early stages by visual assessment, but that can be indicated by a subtle temperature rise.

We conducted a study to measure the temperature of both the wound and the periwound skin. We then compared the temperature pattern with the healing prognosis by using infrared thermography. It was found that if the pressure ulcer has a lower temperature in the wound bed than in the periwound skin, the ulcer tends to heal normally. If the wound bed temperature is higher than the periwound skin, however, healing tends to be delayed (Fig 1). This method of monitoring could be used as a predictor of healing and as a guide to diagnosis and appropriate intervention.

The different appearance in thermographical image between wound bed and periwound skin was the key to distinguish whether the wound will heal or not.

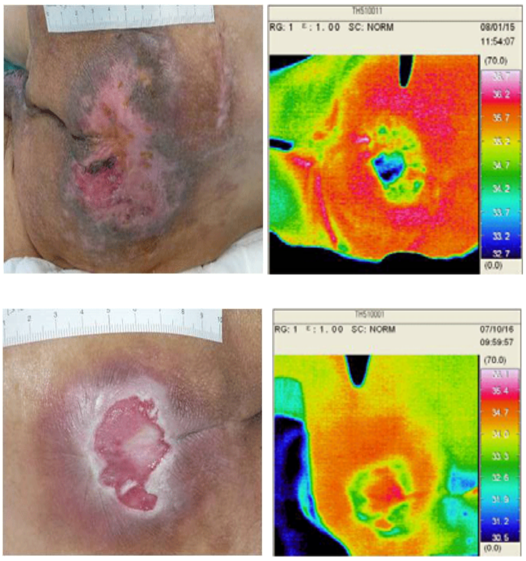


Fig 1: Left, top: pressure ulcer in a patient's sacrum, with ultrasound image showing (right, top): a lower temperature in the wound bed than the periwound skin. This wound healed normally. Left (bottom): pressure ulcer in a patient' sacrum, with (right, bottom): ultrasound image showing a higher temperature in the wound bed than the periwound skin. This wound showed delayed healing

Using research to change practice
Ultrasonographic and thermographic monitoring is now carried out routinely in our hospital on all patients with existing pressure ulcers or at an increased risk of developing them (as identified by the multidisciplinary team). Where abnormalities are shown on ultrasound or thermographic monitoring, interventions including the use of double-layer alternating air mattresses and frequent position changes, and silver or iodine-based dressings, are immediately introduced.

Development of a hand-held pressure measurement sensor to identify actual interface pressure
The risk factors for pressure ulcer development in older patients in Japan are significantly different from those in western countries; this is because older Japanese people tend to have extreme bony prominences (in particular the sacral bone). A tool exists that can measure the projection at bony prominences, and can be used to assess the degree of pressure ulcer risk at this site. However, even when the degree of risk is recognised, the risk cannot be removed entirely.

In Japan, guidelines recommend that nurses turn and change the patient's position regularly to reduce the interface pressure at the bony prominences (this is generally every two hours but there is no agreed consensus) [4] and industry has responded by developing a range of pressure-redistributing mattresses. Although these measures are known to reduce the incidence of pressure ulcers, damage still occurs on occasions. This may be because equipment is not being used effectively or there are problems with the repositioning technique.

Our work focused on adapting an existing tool that monitors interface pressure so that it could be used easily by nurses at the bedside to measure the actual interface pressures that are achieved when pressure-reducing interventions are in place. By using such a tool, an accurate assessment of the effectiveness of interventions can be undertaken, allowing nurses to react and alter treatment appropriately.

Developing the tool

The challenge to develop such a tool was great as it is very difficult to gain an interface pressure measurement between a soft support surface and a hard bony prominence. Safety was also a problem because an industrial pressure sensor is likely to cause skin damage to vulnerable soft tissue. In addition, it was hard to obtain support from commercial companies.

To resolve these problems, we chose a urethane foam pressure sensor because it is a soft material that can adapt to fit to the curves of the body. The system measures the interface pressure by measuring the air leak from the urethane foam, which is proportional to the pressure applied to the sensor; that is, the higher the pressure applied, the larger the volume of air leak.

After verifying the mechanical and physical properties of the sensor, we investigated the threshold of interface pressure associated with pressure ulcer development (Fig 2, Cape Co Ltd; http://www.cape.co.jp/english/) [5]. The results indicated that a threshold level of 40mmHg gave a good indication for predicting reactive hyperaemia. This interface pressure measurement is now recommended in the Japanese *Guidelines for Prevention and Management of Pressure Ulcers* [4].

Fig 2: Interface pressure sensor 'Cello', co-developed with a medical company. The soft sensor pad can safely measure the pressure produced between body and support surface

After introducing this new device into clinical settings, almost all wound, ostomy and continence (WOC) nurses started to measure the interface pressure as an initial risk assessment of pressure ulcer development. The art of pressure redistribution has changed using an effective evidence-based nursing technique.

Developing a specific pressure-relieving mattress for managing patients with extreme bony prominences

In recent years many pressure-relieving mattresses and bed systems have been developed and are available in European countries. However, none of these products seemed appropriate for the patient with extreme bony prominences.

It seemed obvious that there was a need to develop a new mattress that could provide a specific local pressure reduction over specific areas. This could be achieved by changing the air cell shape to a double layer from a single layer at this site. The concept was accepted by a medical devices company (Cape Co Ltd, Kanagawa, Japan; www.cape.co.jp/english/).

A randomised controlled trial was undertaken to evaluate the effectiveness of this product [6]. Patients using the double-layer alternating pressure air mattress developed a significantly lower number of pressure ulcers compared to those using a single-layer air mattress and, unsurprisingly, those nursed on a standard mattress. The pressure ulcer incidence rate was 3.4% in the patients using a double-layer mattress, 19.2% in those nursed on the single-layer and 37.0% of those using the standard mattress.

The data from these studies has led to the introduction of a new regulation for pressure ulcer management by the Japanese government. This specifies that a penalty fee must be paid by the hospital in cases where there is inappropriate pressure ulcer management. Following the introduction of this regulation, there has been a reduction in the prevalence of pressure ulcers in Japan from 4.26 to 3.64%, and the greatest contributing factor is thought to be the introduction of the new air mattress [7].

The Japanese government has also recently introduced an incentive system to encourage specialised nursing care for pressure ulcer management. The government reimburses each hospital 5000 yen (US$45) for every high-risk patient admitted if a WOC nurse is hired as a full-time pressure ulcer manager and provides sufficient and effective care. This is the first time a financial incentive has been used to improve the level of nursing skills in hospitals in Japan. Use of this incentive has spread rapidly throughout the country and has improved the wound healing rate in severe pressure ulcers and is highly cost-effective [8].

Our innovations have had a nationwide impact and have lead not only to clinical changes, but also changes in government regulations.

FUTURE FOCUS

An increasing number of studies have investigated the mechanism of pressure ulcer development. Relatively new concepts such as deep tissue injury and 'critical colonisation' have certainly come about as a result of clinical observation; however, the detailed mechanisms involved can only be elucidated by scientific investigation. Basic science provides the most important background to developments and is a fundamental feature of innovation. For example, pressure ulcers are considered to occur because of prolonged hypoxia induced by tissue damage caused by oxygen and glucose depletion and deposition of toxic metabolites.

However, in recent years, studies of the effects of mechanical force illustrate that this can independently affect cell viability and alter cellular response. A detailed and accurate understanding of the mechanisms involved in pressure ulcer development will be elucidated only with the help of further scientific investigation.

Our research into wound temperature monitoring was inspired by a review on biofilms in chronic wounds by Wolcott *et al* [9]. This review helped our understanding of the relationship between bacteria and host and the molecular biological aspect of this interaction. The concept described recognises the substantial effect of bacterial burden on wound healing. We also believe that bacterial biofilms have a substantial role in wound deterioration and that the full relationship between biofilms and wound healing requires further research. With this in mind, we are working on a biofilm-based full-thickness wound model in rats.

We remain hopeful that the innovative, ongoing work on pressure ulcer management will provide better options for the many patients suffering from pressure ulcers.

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Page Points

- *Research and development initiatives in pressure ulcer management and prevention have dramatically improved the outcome and quality of life for many patients in Japan*
- *Ultrasound can be used to identify changes in deep tissues in pressure ulcers and predict the likely deterioration allowing early use of appropriate interventions*
- *The temperature in the wound bed can be measured using thermography as a guide to healing prognosis*
- *A hand-held device to measure interface pressure is an important tool for measuring projection of bony prominences, a particular risk factor for pressure ulcer development in patients in Japan*
- *A double-layer alternating pressure air mattress was developed to provide local pressure reduction over specific areas*
- *Significant reductions in pressure ulcer recurrence were achieved using the specifically designed mattress for patients with extreme bony prominences*
- *Incentives have been introduced by the Japanese government to help reduce pressure ulcer prevalence and improve standards of care for patients in Japan*
- *Future focus must be on scientific investigation to develop a detailed and accurate understanding of the mechanisms involved in pressure ulcer development*

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Expert Commentary

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Comment on role of biofilms in chronic wounds

Biofilm, a society of surface-associated bacteria residing in a self-secreted matrix, 'infects' humans very differently from single cell (planktonic) bacteria. This was the main point of our article *Biofilms and chronic wound inflammation*, published in the *Journal of Wound Care*[1]. Dr Scot Dowd was able to outline several molecular mechanisms by which biofilm, utilising its colony defences, is able to commandeer host immunity and produce persistent hyper-inflammation in the wound bed. This explains why chronic wounds are 'stuck' in the chronic inflammatory state, but also lays the groundwork for molecular mechanisms by which biofilm prevents healing of wounds.

We felt it was important for the reader to understand that biofilm-phenotype bacteria infect quite differently and follow a parasitic strategy. By appreciating the biology of bacterial biofilms along with the host-microbe interactions, the wound care practitioner now has a foundation to implement innovative wound care strategies.

We have reported in previous publications that by focusing on wound biofilm as a major barrier to wound healing, healing outcomes can be significantly improved [2,3]. We suggest that wound biofilm, and therefore chronic wound inflammation, can be suppressed by following multiple concurrent strategies including frequent debridement followed by treatments that block the reaccumulation of wound biofilm. This can be done with multiple simultaneous treatments with agents that block reattachment, degrade colony defences, target the regrowing bacteria, block quorum sensing communications, degrade the extracellular polymeric substance the bacteria secretes, and more [4-8].

The realisation that bacteria can form polymicrobial communities that possess multiple defensive and offensive strategies to produce chronic infections such as chronic wounds, has created a whole new set of challenges and opportunities in wound healing. For example, the different bacterial species present have not been well identified by clinical cultures, yet molecular methods show that the bacterial species in wounds are much more diverse than we had ever thought possible [9-11]. Extra complexity is added when the synergies between these different species are considered. The communication language (quorum sensing) between bacteria of the same species or different species is just now being revealed. As we learn to control this communication language we can further exploit weaknesses in the wound biofilm. By degrading biofilm defences we can make wound biofilm more sensitive to temperature, oxygen, nutrients, bacteriophages, UV light, antibiotics, biocides and other 'natural' stresses. Targeting the ability of wound biofilms to shelter from these forces allows us to start using them as simultaneously applied adjuncts in biofilm suppression and therefore wound healing.

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