

# Examining the Carital Optima air-float mattress through patient experience and pressure mapping

Pressure ulcers can be very painful and distressing for patients and present a significant management problem for healthcare professionals. Over the past few years, a wide variety of mattresses have become available for at-risk patients that aim to provide a pressure-redistributing support surface. One of these products, the Carital Optima mattress, has been designed for a wide range of dependent patients who are being nursed with or without existing pressure area damage. This article details a pressure mapping exercise and looks at three patient case studies to assess the efficacy of the Carital Optima mattress.

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## KEY WORDS

Pressure ulcer  
Mattress  
Pressure mapping  
Case studies

Having a pressure ulcer can be a painful and distressing experience with physical, psychological, social and economic consequences for patients, their families and healthcare facilities. Hibbs (1988ab) and Waterlow (1988) state that the majority of pressure ulcers are preventable. Indeed, subsequent published evidence supports this, claiming that the majority of pressure ulcers are preventable (a 5% incidence being the lowest achievable rate with current knowledge, equipment, and practice) (Harrison et al, 2008; Rashotte et al, 2008).

Jay (1995) has identified five key extrinsic factors thought to be the

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causative factors of pressure ulcer damage:

- ▶▶ Pressure
- ▶▶ Shear
- ▶▶ Friction
- ▶▶ Moisture
- ▶▶ Skin temperature.

While considering the extrinsic factors, the clinician also has to consider the wide range of intrinsic factors that cannot be changed, such as the patient's age, sex and physical status, as well as the intrinsic factors considered amenable to therapy or modification, such as disease condition and nutritional and fluid status. All of these have to be taken into account when planning and choosing the appropriate mattress support surface.

Data has been published indicating that the appropriate use of effective pressure-relieving support surfaces, together with routine nursing interventions, is central to avoiding pressure area damage in at-risk patients as well as facilitating healing where ulceration is in evidence (Wolverton et al, 2005; de Laat et al, 2007; Walsh and Plonczynski, 2007).

The Carital Optima mattress has been in production for 12 years and has sold over 10,000 units in the UK, Norway, Denmark, Finland, Holland, Germany, Switzerland, Australia, United States and Japan. About 800,000 patient

uses have been recorded in the acute sector and 120,000 in long-term care. In the time that the mattress has been in manufacture there have been no adverse clinical incidents reported to the manufacturer.

## Mattress types

Over the past few years, a wide variety of mattresses have become available for at-risk patients (Rithalia and Kenney, 2001). These mattresses are pressure-redistributing support surfaces that can be divided into various groups depending on their characteristics:

### Group one

The first group of mattresses is comprised of pressure-reducing surfaces that attempt to minimise interface pressure over the body's bony prominences. This is achieved by maximising the amount of body surface area that is in contact with the mattress. This type of mattresses is divided into either:

- ▶▶ Static non-powered systems: these include those comprised of foam, visco-elastic, gel, liquid, fibre or inert air cells
- ▶▶ Dynamic-powered systems: these are low air-loss or hybrid mattresses such as the Softform Premier Active (Invacare UK, Bridgend), a static foam mattress with alternating cells below a foam top layer
- ▶▶ The Carital Optima (Nexus DMS, Droitwich) low air pressure system.

### Group two

The second group is comprised of dynamic, powered systems that use alternating pressure air mattresses (APAMs). These incorporate alternately inflating and deflating air cells, which apply then remove pressure over the body's interface contact points and aim to stimulate reactive hyperaemia on a programmed basis.

Some mattresses combine both dynamic systems in the form of a continuous low pressure alternating system that can also function in continuous low pressure mode without alternating the cells. These are APAMs that optionally can also function as a low air-loss system.

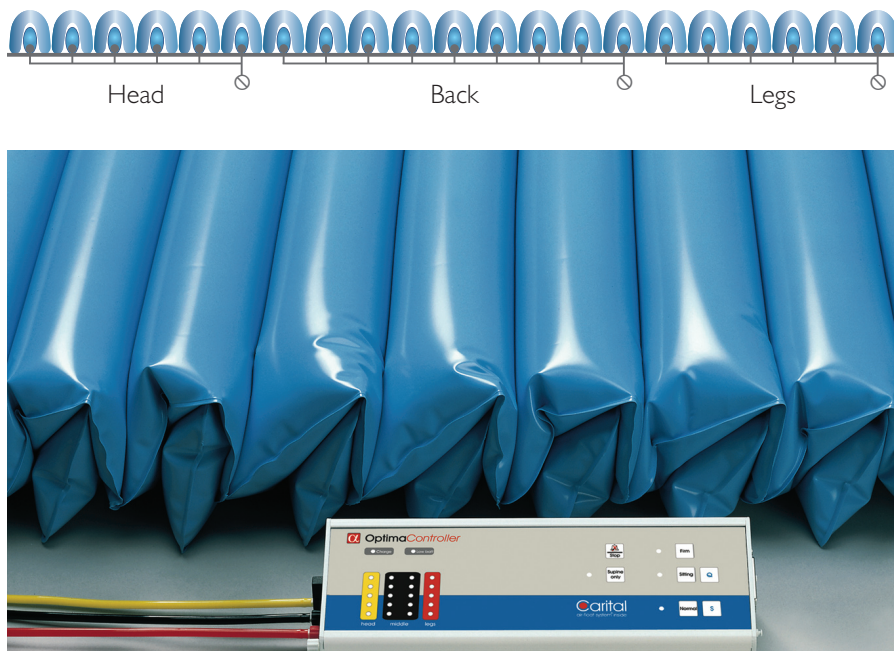
Different mattress types are useful in that they provide the clinician with a range of options to suit the individually assessed needs of the client and can be used to reduce pressure ulcer risk status following a holistic risk assessment (National Institute for Health and Clinical Excellence [NICE], 2005).

However, APAMs can have drawbacks, including:

- ▶▶ Noisy pump units on some models can be especially disturbing at night (Beldon, 2002)



**Figure 2. The Carital Optima mattress plus cover and controller.**



**Figure 1. Side view of the Carital Optima mattress with diagrammatic representation of the cells.**

- ▶▶ Patients can complain of discomfort (Nixon, 2006)
- ▶▶ Motion sickness can be a problem for some patients (Beldon, 2002)
- ▶▶ Amputees, especially bilateral amputees, cannot reposition themselves or may experience difficulty getting on and off
- ▶▶ Some patients may experience movement down the bed, where they 'migrate' or are progressively drawn down the bed by the APAM cell cycle (Collins and Hampton, 2000)
- ▶▶ Some patients can experience an exacerbation of wound pain when in contact with APAMs
- ▶▶ Sleep disturbance in those patients with multiple sclerosis and Alzheimer's disease has also been reported (Chokroverty, 1996).

The Carital Optima mattress has been designed to address these problems.

### The Carital Optima mattress

The Carital Optima mattress is a dynamic electrically powered mattress which although it has air cells is neither an APAM since it does not alternate, nor a low air-loss system, but functions by supporting the patient with the air-cells filled at lower pressures than that needed for an APAM. It

has been designed to overcome the disadvantages of APAMs and is intended for a wide range of dependent patients who are being nursed with or without existing pressure area damage. It is designed for use in a wide range of clinical areas, including acute, chronic or community settings, such as intensive care units, medical/surgical/elderly care wards, nursing homes or domiciliary settings.

The mattress comprises a base unit overlaid with a patented double cell structure, where each cell is located inside another (Figure 1). The mattress is made up of 21 of these double air cells, with the upper cells adapting to different body contours to provide the maximum contact area between the mattress's surface and the patient's body surface area.

Each upper cell contains a series of interconnected adjustable inner cells that are connected to a controller (pump) unit, which inflates the inner cells. The cells are divided into three compartments – six cells each for the head and leg sections, plus a central block of nine cells for the torso.

None of these cells go through an alternating cycle so the mattress is not classed as an APAM.

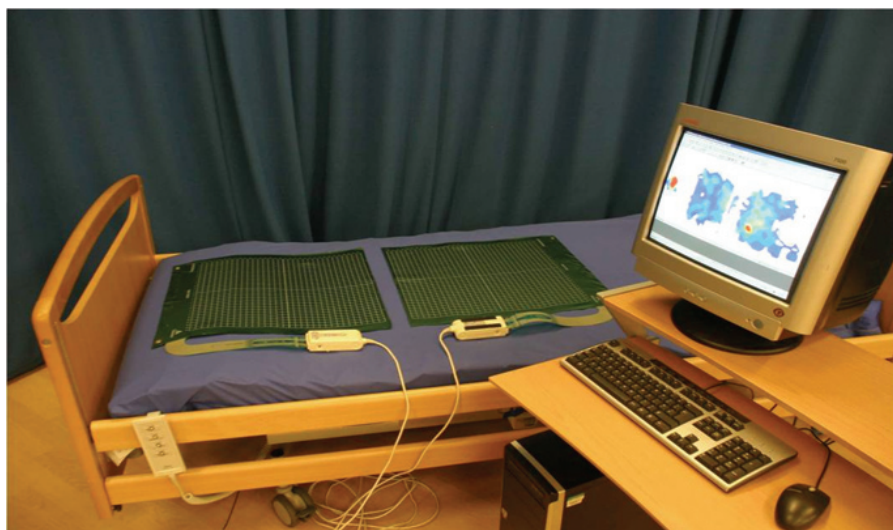


Figure 3. The Carital Optima mattress with the double Tekscan mat in situ.

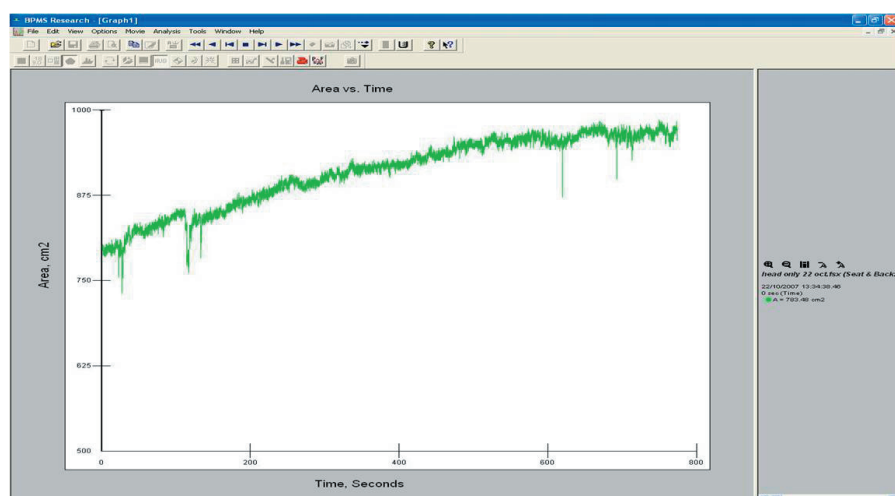


Figure 4. A typical graph acquired from actual data showing a calculated increase in contact area with time. This plot covers a single cycle of the mattress's pressure equilibration (15 minutes).

Features of the Optima mattress include:

- ▶▶ Patented double-cell structure
- ▶▶ Large contact area
- ▶▶ The mattress reduces interface pressure and keeps tissue strain to a minimum in all user positions
- ▶▶ Separate cell systems react to body part weight, profile and position, distributing the load over the whole surface
- ▶▶ The tunnel-shaped, pre-filled upper cells adapt exactly to different body contours
- ▶▶ The inner cells are inter-connected to form three adjustable zones
- ▶▶ The zones are monitored by pressure sensors, which respond to user movement
- ▶▶ The computerised controller automatically and precisely adjusts cell pressures over a wide patient weight range
- ▶▶ The simple-to-use controller is compact, light and quiet
- ▶▶ The pump operates only on demand
- ▶▶ The built-in battery provides continued use during patient transfers
- ▶▶ The mattress incorporates an emergency pull-strap for cardio-pulmonary resuscitation purposes (CPR) which when re-fitted will enable the mattress to re-inflate with the patient on the mattress
- ▶▶ An incontinence cover is supplied as standard
- ▶▶ The individual cells are easy to replace

- ▶▶ It is easy to get on and off the mattress
- ▶▶ The mattress is available in bariatric presentation for heavier patients and a smaller version is also made for neonates and infants.

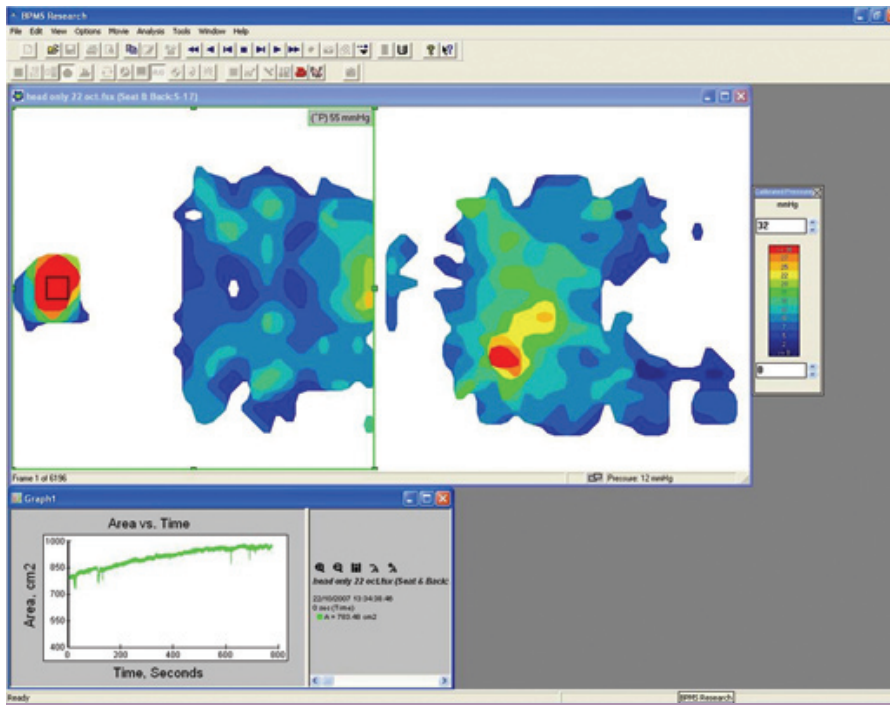
Before placing the patient on the mattress the nurse can adjust the pressures in the upper cells to cater for the individual patient's risk status while the lower cells can be adjusted via the controller unit (Figure 2).

The mattress has a highly breathable a three-layer textile cover that provides a two-way stretch reducing the risk of hammocking. It also has a waterproof and vapour-permeable cover, preventing contaminant ingress to the inner components of the mattress, as well as preventing the build up of moisture on the patient's skin, lowering the chances of maceration, shear and friction damage (Lowthian, 1997). All the seams are welded, which helps to minimise the risk of fluids gaining access to the inside of the mattress.

The Optima management unit (pump) is almost silent when operating, which, coupled with the high level of comfort due to the mattress not being an APAM, and the maximised body-to-surface contact, contributes significantly to comfort levels and patients' quality of sleep. It is recognised that some pressure-relieving mattresses improve patient sleep, and thus quality of life by virtue of their impact on pain sensitivity (Price et al, 2003). This is particularly evident in patients suffering from multiple sclerosis or motor neurone disease (Chokroverty, 1996). Limited clinical experience of nursing such patients on the Carital mattress shows such pain relief and sleep improvement, however, is the subject of ongoing clinical study.

The mattress facilitates nursing and physiotherapy interventions by using a stabilisation mode which defaults to function mode after 15 minutes – this can be re-instituted if therapy has not been completed.

This stabilisation mode has been found to be most suitable for amputees



**Figure 5. Pressure map of the contact between the body and the mattress. Areas of equal pressure are all the the same colour calibrated according to the colour scale on the right in mmHg. The highest pressures are shown in red.**

who can get on and off with greater ease and can stabilise the mattress surface before returning to bed with minimal or no assistance from others.

The mattress also incorporates audible and visual alarms, including power failure and high or low pressure indicators.

### Pressure mapping

The aim of this study was to investigate the performance of the Carital Optima mattress using dynamic interface pressure measurements. This work was performed under laboratory conditions with healthy volunteers. The bed and mattress were set up and calibrated according to the manufacturer's instructions. Each subject rested upon the mattress in a supine and lateral position for one full cycle of the mattress pressure adjustment (the equilibration cycle). Data acquisition was performed using a Tekscan Dual Mat system at 8Hz via a USB port (Figure 3) which measures interface pressures between the patient and the mattress. Data was captured for the duration of the 15-minute equilibration cycle and the two mats were positioned to provide continuous coverage. The cycle

allows the cells of the mattress in head, thorax, and leg segments to adjust their pressures to give the maximum support for the subject. In effect, the contact area between mattress and subject is increased, thus reducing local pressure. The cycle is activated by the movement of the subject.

Care was taken to ensure that the mats were positioned consistently in relation to the underlying structure of the Optima mattress and that the measurement surface was not folded or creased during loading. The maximum interface pressure and mean contact area were then measured.

The results illustrated that, over time, the mattress adjusts to increase the contact area between the body and mattress – thus reducing pressure. Typically, area increases of 25% have been obtained (Figures 4 and 5) among all subjects evaluated in the study to date. This information is more informative than the single-point pressure values obtained on small areas with static measurements as it shows how the mattress's cellular structure adjusts to the contours of the human body by reducing the air pressure in

heavily loaded areas and increasing pressure in the lightly loaded areas — thus redistributing the total pressure. This technology permits pressure mapping once the subject has changed position and triggered the mattress' equilibration cycle.

According to separate studies conducted by Soppi and Takala (2005) and White et al (2007), the Carital Carital Optima mattress effectively reduces the pressure between the patient and the support surface. This translates clinically into prevention of ulceration in acute respiratory failure (Takala et al, 1996), and, in the authors' ongoing formal evaluations, pain relief and improved sleep in a variety of chronic disorders.

### Case report one

The patient, aged 81 years, had Alzheimer's disease for several years. She had severe contractures to all four limbs, was underweight and unable to verbally communicate, although she could produce facial expressions signifying pain, comfort and approval/disapproval of nursing interventions.

She had been resident in a nursing home since 2003 and required permanent urinary catheterisation and frequent attention for faecal incontinence. She also needed repositioning every two hours, a time frame established by the care team as most comfortable for her. The patient was totally dependent on nursing staff for all of her care and was restless at night with a poor quality of sleep.

During the summer of 2007, she became unwell with pyrexia that required antibiotics. She also developed a grade 4 sacral ulcer (EPUAP, 1998) that measured 5.5cm long X 5.2cm wide and was 3cm deep with 80% slough over the wound bed and 20% non-granulating tissue. Dressing changes using Aquacel Ag (ConvaTec, Ickenham), as prescribed by the primary care trust's tissue viability nurse were required frequently due to faecal incontinence. Morphine was also required for pain caused by the dressing changes.

The patient was placed on an APAM, which caused her some distress and there was no improvement in the ulcer after several weeks. Thus this led to the decision to nurse the patient on a Carital Optima mattress. The patient's facial features visibly relaxed when she was placed on the mattress, which her care team interpreted as an expression of comfort.

She remained on the Optima mattress for four months, with two-hourly repositioning being maintained each day. On turning, her dependent bony prominences were observed to be free of marking, including blanching erythema, in spite of her having rested on her trochanter for the previous two hours. This feature was maintained for the entire time she used the Optima mattress.

The sacral pressure ulcer slowly improved, becoming smaller, with 90% of the wound bed comprising granulation tissue and the remaining tissue being covered with a thin sloughy film. The surrounding skin became a healthy pink, which blanched on finger pressure.

During the evaluation, no new tissue damage occurred and she had an improved quality of sleep as well as a reduction in the need for morphine. Care staff also stated a preference for the Optima mattress system over their current APAM stock.

### Case report two

The patient was a 79-year-old woman who lives alone. She had suffered from osteoporosis and rickets for many years, which had been treated with daily calcium drinks. A scan indicated that her bone density had deteriorated and this had caused her problems with pain and posture. The patient assessment revealed a grade 4 pressure ulcer (EPUAP, 1998) and Waterlow score was 16 (high risk).

The patient was a former smoker and a bilateral amputee (right above knee and left below knee) due to unhealing leg ulcers of unknown aetiology. This caused her problems in maintaining posture, especially when

'walking' over the top of her mattress into and out of her wheelchair. She weighed 31 kg and was self-caring at home, with the assistance of one carer for personal care and a district nurse for wound care. She had a chronic grade 4 pressure ulcer (EPUAP, 1998) to her left ischial tuberosity, which has been present for more than four years. She was spending up to 14 hours in her wheelchair each day.

The patient's main problems on assessment included discomfort and pain, disturbed nights, problems with transfer from her wheelchair and maintaining independence, problems in maintaining posture, low body weight, and a chronic unhealing wound. The team felt it was important that the pain and discomfort were relieved, as this has been shown to have a significant impact on quality of life and wound healing (Vileikyte, 2007). The patient also had many allergies, including those to wound products and black dye from some mattress covers, therefore, the colour of any mattress cover and the selection of dressings had to be carefully considered.

The skin over the patient's buttocks was periodically breaking down, forming blisters and grade 2 damage. This healed over time independently of the dressing choice or mattress selection, but required the attention of a dermatologist. The patient was also prescribed analgesia, including morphine sulphate and co-proxamol, plus she also drank a large sherry at night.

In an attempt to take pressure off her buttocks and sacral ulcer, an increase in bed rest was discussed with her. However, this has been tried in the past and she had been hospitalised on several occasions in order to try and improve her overall tissue viability. As a result, she would not consider this as an option as it was very important to her that she remained independent at home. The wound was assessed and an appropriate dressing used to debride and encourage granulation. The patient's wheelchair cushion and mattress were also assessed, which included pressure mapping.

The patient was using a static replacement foam mattress that she found uncomfortable, with high interface pressure mapping results over the bony prominences causing her to have a disturbed sleep pattern. She stated that she had not had a full night's sleep in many years and that pain and/or discomfort usually woke her up every hour.

As well as being uncomfortable, the static replacement foam mattress was unsuitable from a pressure-relieving perspective. About four different mattresses were, therefore, trialled to try and find a solution. However, none were found to be ideal, especially an APAM, which she found uncomfortable, transferred her down the bed at night and was impossible for her to transfer onto as it had poor surface support for her uneven stumps. Other mattress types trapped her skin between their cells.

The qualities of the Optima mattress were discussed with the patient, who agreed to try one over a six-week period. On being introduced to the mattress, she was immediately able to self-transfer onto the 'firmed' mattress un-assisted and could 'walk' across the surface with ease. Her pain score reduced to 3 according to The Universal Pain Assessment Tool (0 = no pain; 10 = worst pain possible) and all night-time analgesia was discontinued.

The patient stated that: 'It's the first time in years that I can honestly say that I've had a comfortable night's sleep.' She also felt comfortable and supported on the Optima mattress and her transfers were easily managed by using the 'firm' button. In fact, she was able to transfer alone if she took it slowly and carefully but preferred to have a carer present.

After six weeks of using the Optima mattress, the patient's wound has begun to improve, granulation had appeared and the wound had reduced in size and depth. This was in spite of the patient still sitting in her wheelchair for 14 hours per day.

A more accurate evaluation of the wound will be made after three months. In the meantime, rather than wait for the primary care trust to fund an Optima mattress, she has elected to purchase one from her own resources — meaning she will not have to revert to using any other type of mattress once the evaluation period is over.

### Case report three

The patient was 56-years-old and had been paraplegic for about 46 years following an accident. For most of the time he stayed at home with an electric bed and an APAM, which was supplied by his local Community Loan Centre.

For many years he has had recurring pressure ulcers (grades 1–4) (EPUAP, 1998) and had become an expert patient with regards ulcer formation, different mattress types and the value of electric-profiling beds.

From time to time he had been admitted to a specialist spinal injuries unit for reassessment or surgical intervention, either to his soft tissues or bones. In June 2008 he was admitted for reconstructive surgery on two pressure ulcers after unsuccessful reconstructive surgery at another hospital.

While he was undergoing pre-operative evaluation, he was offered the use of an Optima mattress and although he found it comfortable over his remaining sensate areas, he asked to be placed on an APAM after 48 hours as he had become concerned that the Optima mattress had 'bottomed out'. However, during transfer to the APAM, the staff noted that no new skin damage or markings had occurred.

After a discussion about the functional differences between the Optima mattress and an APAM, the patient accepted that the principles of continuous low pressure could be beneficial and agreed to go back on the Optima mattress to complete a three-week period of total post-operative bed rest.

Reconstructive surgery was performed and over the next three

weeks the patient remained on the Optima mattress, receiving regular repositioning, skin inspection and nursing care. Photographs of pressure areas were taken each week to assess the healing process.

Throughout this time no new skin breaks occurred and all the patient's bony prominences remained intact and free from blanching and non-blanching erythema. The consultant surgeon, ward staff and tissue viability nurse all expressed confidence in the Optima mattress and had no concerns about him continuing to be supported by it.

The patient appreciated the added comfort the Optima mattress provides – he was especially impressed by the non-appearance of 'pink marking' over his bony points. His principle concern is that when he is transferred home he will have to return to his Community Home Loans APAM and wants the primary care trust to purchase an Optima mattress for him.

### Conclusion

In the absence of a randomised clinical evaluation, the purpose of this article is to report on at least three patient outcomes from three different care environments which borrowed a Carital Optima mattress from Nexus for their own evaluation purposes.

Over the years many different types of static and dynamic mattresses have been produced and careful selection is required by clinicians in order to avoid inappropriate use and possible harm to patients.

When evaluating the efficacy of new mattresses, interface measurements using pressure mapping is a common approach (Fletcher, 2006) and the technology used for the Optima mattress is recognised as being scientifically valid (Agam and Gefen, 2007).

Equipment selection should also be based on a holistic assessment of individual patient need (NICE, 2005), in order to identify the suitability of the

### Key Points

- ▶▶ The Carital Optima mattress is a unique, electrically-powered reactive speciality surface suitable for reducing pressure ulcer risk status, and, for promoting pressure ulcer healing.
- ▶▶ More than 800,000 patients worldwide have used the Carital Optima mattress over the past 12 years.
- ▶▶ The mattress adjusts to individual patient surface characteristics to increase contact area and thus reduce interface pressure.
- ▶▶ It not induce motion sickness in patients, nor transfers patient down the bed.
- ▶▶ Quality of comfort and improvements in sleep pattern have been reported following use of the Carital Optima mattress, resulting in reduced pain scores and analgesia dosage — particularly useful for MS and MND patients.

equipment for the patient and the care setting as well as providing patient choice.

Dynamic mattresses have been available for many years, with APAMs being the dominant type used in the UK. However, APAMs have certain drawbacks, such as pump noise, motion sickness, exacerbation of pain in existing wounds, sleep disturbance and patient migration down the bed.

Throughout the time the authors were studying the three patients featured in this article, the lack of pump noise was noted by staff and those patients able to comment.

This is important as noise from machinery, especially at night, can be a contributory factor to sleep disturbance for the patient and any others in the vicinity. The lack of sleep and its impact on wound healing has been noted by Cole-King and Harding (2001) who identified the positive effect on wound healing of good sleep patterns and delays in healing due to lack of sleep.

In case two, the patient had a grade 4 pressure ulcer that showed no sign of healing, however, in spite of spending most of the day in a wheelchair, her ulcer began to granulate. This could have been due to the benefits of having a full night's sleep through using the Optima mattress.

None of the patients featured in this article experienced migration down the bed. This benefits both patient and staff from a moving and handling and a health and safety perspective. Again, this was of immense benefit in case two as the patient was able to get out of bed unaided from a safe position.

Through reviewing the available, published literature on the Optima mattress, verifying the validity of pressure-mapping undertaken on behalf of the manufacturer and specifically reporting on three patients in three different healthcare environments, it would seem that the Carital Optima mattress offers a unique type of support surface for pressure ulcer prevention, pain relief, comfort and sleep promotion. Added benefits include a reduction in the amount of medication needed, ease of get in and out of bed and elimination of motion sickness and migration down the bed.

These evaluations have shown the Carital Optima mattress to be a promising alternative to APAM mattresses. In conjunction with other published evidence, this article forms an evidence base that healthcare professionals can use to make an informed choice about patient care. **WUK**

### Acknowledgements

Thank you to the following clinicians who allowed access to their patients in the case studies: Alison Lamb, Oswestry; Maggie Dowling and staff of the Highfield Nursing Home, Ryde, Isle of Wight. Nexus DMS has provided the University of Worcester with an educational and research grant to conduct the pressure monitoring and case studies.

### References:

- Agam L, Gefen A (2007) Pressure ulcers and deep tissue injury: a bioengineer's perspective. *J Wound Care* 16(8): 336–42
- Beldon P (2002) Transfoam Visco: evaluation of a viscoelastic foam mattress. *Br Med J* 11(9): 651–5
- Chokroverty S (1996) Sleep and degenerative neurological disorders. *Neurol Clin* 14(4): 807–26
- Cole-King A, Harding KG (2001) Psychological factors and delayed healing in chronic wounds. *Psychosomatic Med* 63: 216–20
- Collins F, Hampton S (2001) A guide to the selection of specialist beds and mattresses. *J Wound Care* 13(5): 14–18
- de Laat EH, Pickkers P, Schoonhoven L et al (2007) Guideline implementation results in a decrease of pressure ulcer incidence in critically ill patients. *Crit Care Med* 35(5): 815–20
- EPUAP (1998) *Pressure Ulcer Prevention and Treatment Guidelines*. Available from [www.epuap.org/](http://www.epuap.org/)
- Fletcher J (2006) Equipment selection. In: Romanelli M, Clark M, Defloor T et al (Eds). *Science and Practice of Pressure Ulcer Management*. Springer-Verlag, London: 59–68
- Hibbs P (1988a) The economics of pressure ulcer prevention. *Decubitus* 1(3): 32–8
- Hibbs P (1988b) Tissue viability. *Nurs Times* 84(13): 68–73
- Jay R (1995) Pressure and shear: their effects on support surface choice. *Ostomy Wound Manag* 41(8): 36–45
- Harrison MB, Mackey M, Friedberg E (2008) Pressure ulcer monitoring: a process of evidence-based practice, quality, and research. *Jt Comm J Qual Patient Saf* 34(6): 355–9
- Lowthian P (1997) Alternating-pressure air mattresses: the Quattro range. *Br J Nurs* 6(14): 177–9
- NICE (2003) *Pressure ulcer prevention. Pressure ulcer risk assessment and prevention; including the use of pressure-relieving devices for the prevention of pressure ulcers in primary and secondary care*. NICE, London [www.nice.org.uk](http://www.nice.org.uk)
- Nixon J, Cranny G, Iglesias C et al (2006) Randomised, controlled trial of alternating pressure mattresses compared with alternating pressure overlays for the prevention of pressure ulcers: PRESSURE (pressure relieving support surfaces) trial. *Br Med J* 332: 1413–5
- Nixon J, Nelson EA, Cranny G et al (2006) Pressure-relieving support surfaces: a randomised evaluation. *Health Technol Assess* 10(22): iii–iv, ix–x, 1–163
- Price P, Rees-Mathews S, Tebble N, Camilleri J (2003) The use of a new overlay mattress in patients with chronic pain: impact on sleep and self-reported pain. *Clin Rehabil* 17(5): 488–92
- Rashotte J, Thomas M, Gregoire D (2008) Implementation of a two-part unit-based multiple intervention: moving evidence-based practice into action. *Can J Nurs Res* 40(2): 94–114
- Rithalia S, Kenney L (2001) The art and science of evaluating patient support surfaces. <http://www.worldwidewounds.com/2001/september/Rithalia-and-Kenney/Evaluating-Support-Surfaces.html>
- Waterlow J (1988) The Waterlow card for the prevention and management of pressure sores. *Science Care Practice* 6(1): available from [www.judy-waterlow.co.uk/downloads/Waterlow%20Score%20Card-front.pdf](http://www.judy-waterlow.co.uk/downloads/Waterlow%20Score%20Card-front.pdf) last accessed: August 21st 2008
- Soppi E, Takala J (2008) Carital specialty mattress in the management of pressure sores. Poster presentation, EWMA
- Takala J, Varmavuo S, Soppi E (1996) Prevention of pressure sores in acute respiratory failure: a randomised controlled trial. *Clin Intens Care* 7(5): 228–35
- Vileikyte L (2007) Stress and wound healing. *Clin Dermatol* 25(1): 49–55
- Walsh JS, Plonczynski DJ (2007) Evaluation of a protocol for prevention of facility-acquired pressure ulcers. *J Wound Ostomy Cont Nurs* 34(2): 178–83
- White RJ, Bevins J, Stephen-Haynes JA (2007) Interface pressure measurements on the Carital mattress. Poster presentation, Wounds-UK, Harrogate. Available from [r.white@worc.ac.uk](mailto:r.white@worc.ac.uk)
- Wolverton CL, Hobbs LA, Beeson T et al (2005) Nosocomial pressure ulcer rates in critical care: performance improvement project. *J Nurs Care Qual* 20(1): 56–62