Oxygen and Omnilux® in wound healing

A course of hyperbaric oxygen precedes a course of light-emitting diodes to aid the healing of a lower lumbar soft-tissue radiation injury

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Abstract

Ruby is a 55-year-old professional lady who has suffered pain and poor wound management of a lower lumbar soft tissue radiation injury following treatment of metastatic disease. Ruby's primary lesion was a poorly differentiated carcinoma of her left breast. This review of her wound management explores the manner in which patient autonomy and an adjunctive treatment option contributed to an improvement in her skin integrity and personal wellbeing.

Keywords: irradiated tissue, hyperbaric oxygen/hyperbaric therapy, Omnilux™ light therapy, light-emitting diodes (LEDs).

Past medical history

Ruby (*pseudonym*) was diagnosed with a poorly differentiated carcinoma of the left breast in 1998. Following chemotherapy and radiotherapy she underwent a transverse rectus abdominis myocutaneous (TRAM) free flap and extensive surgical reconstruction. By June 2001 she was in clinical remission and taking oral Tamoxifex. In December 2005 Ruby experienced several episodes of uncharacteristic pain. Following a sestamibi scan that demonstrated a parathyroid adenoma (which was subsequently excised during a limited parathyroidectomy in February 2006), Ruby was diagnosed with a recurrence of her breast cancer along with metastatic disease in her lumbar spine. Once again she endured a course of radiotherapy involving her left breast and lower lumbar area.

In August 2007 Ruby was admitted to hospital for investigation of lower lumbar pain and tingling in her right foot. An magnetic resonance imaging (MRI) scan at this time revealed a severe metastatic compression fracture of L5 with extension to post-neural elements, compression of left L5 nerve root with tumour, metastatic deposits in the body of L4, metastatic infiltration to the right iliac bone and possible spread to S3. She received further radiotherapy to her spine which ultimately resulted in the soft tissue radiation injury to the lower lumbar region (Figure 1).

Current issues

By 2010, Ruby's medical condition had deteriorated significantly and included asymptomatic bilateral hydronephrosis requiring ureteric stents. She considered this to be only a minor hiccough as she saw the major issue in her life was the recurring soft tissue breakdown of the irradiated lower lumbar region with its high levels of exudate. This was the cause of considerable pain, discomfort and social adjustment which was impacting notably on her quality of life by preventing participation in pursuits she enjoyed and limiting her activities of daily living. She resented the inconvenience and limitations this brought about and the radical lifestyle changes that were required to manage the wound.

Serious complications from therapeutic radiation are rare and occur in only a small percentage of patients[1]. Signs and symptoms of radiation injury typically develop after a

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quiescent period that may extend from many months through to many years following treatment. The aetiology of delayed radiation injury is not well understood but there is certainly a concurrence of thought on endarteritis, tissue hypoxia as well as fibrosis being major contributors to the pathogenesis of the injury[2]. There are four recognised periods or sequence of events in the clinical radiopathologic response of normal tissue to radiation. The acute and subacute clinical periods take up the first 12 months following the administration of radiation treatment. Clinical changes are determined by the degree of silent corrosion to the vasculature and make their appearance accordingly. The chronic clinical period (second to fifth year) and late clinical period (greater than five years) show advancement of permanent residual damage with the most crucial issues arising from the chronic deterioration of the microvasculature and the associated hypoperfusion that results[3]. Ruby's lumbar wound presentation correlated with the chronic clinical period as the radiopathologic sequence of events was almost four years since her radiotherapy. Painful ulcerations occur much more frequently in the chronic clinical period and are notoriously slow and difficult wounds to heal completely.

Until May 2010, the continual breakdown and loss of skin integrity had been managed by Ruby in conjunction with her general practitioner. The wound measured 20 cm x 15 cm and Ruby reported it to be incredibly painful at 9/10. However, it was not the pain that prompted Ruby to seek specialist wound management advice but the increasing amounts of exudate that she was forced to manage. It became the most prominent issue in her day and Ruby saw this as an intrusion into her life that she wanted to control. Management of constant pain and wet clothes, coupled with the high financial outlay for dressing products prompted Ruby to search for possible treatment options.

Hyperbaric oxygen

The Diving and Hyperbaric Medicine Department of the Royal Hobart Hospital first assessed Ruby in May 2010. A thorough wound assessment was undertaken during her initial visit to the department. Significant inflammation and irritation was noted along with high levels of serous exudate. A wound grid tracing taken at this visit showed the irradiated area measured 20 cm x 15 cm. Several areas of epithelial loss were evident, with associated covering of sloughy tissue. Estimated depth of these areas was 2–3 mm. Transcutaneous oxygen measurements (TCOM) were undertaken at this visit and showed readings breathing room air at 1ATA (atmospheres absolute) were 55–74 mmHg (Figure 1).

Values above 40 mmHg are considered an indication of sufficient oxygen supply to support tissue repair and wound

Figure 1. May 2010 Ruby undergoes $TcPO_2$ assessment.

healing. Values between 20 and 40 mmHg are considered an unclear range in terms of wound healing and values below 20 mmHg generally indicate ischaemia and an inability to heal[4,5]. An oxygen challenge delivering 100% O_2 via a closed-hooded system at 1ATA was given and Ruby's TCOM readings displayed a range of 191–406 mmHg.

Low TCOM measurements that rise above 100 mmHg breathing 100% oxygen at 1ATA support the usefulness of hyperbaric oxygen in wound healing[6]. Ruby's TCOM readings (55–74 mmHg) breathing room air at 1ATA showed normal levels of O_2.

TCOM probes are not able to be placed directly on the damp surface of the wound and, therefore, have to be placed on the peri-wound area, which is usually viable tissue, thereby showing readings not truly reflective of the wounded area. The centre of an irradiated wound is unmistakably hypoxic, with a gradual increase in oxygen tension moving outward from the centre of the wound towards non-irradiated viable tissue. This is consistent with the known characteristics of tissue damaged by radiotherapy treatment, which lessens with distance from the central point of the beam[2].

A course of hyperbaric oxygen was offered and Ruby began an initial programme of 40 treatments. This was once daily Monday to Friday at 2.4ATA for 90 minutes per treatment. Oxygen is administered via a closed system using an Amron hood (Figure 2). In the early 1980s, Robert Marx studied the effect of hyperbaric oxygen on healing of problematic wounds resulting directly from irradiated tissue after oral and maxillofacial surgeries. He observed that patients who received a minimum of 20 hyperbaric treatments for radiation injury to sites other than the mandible were found to respond in the same fashion with effective capillary angiogenesis and fibroplasia[5].

Figure 2. A patient demonstrates the oxygen delivery system (reprinted with permission of the patient).

Ruby's wound management during this time involved the use of silicone products for their comfort, ease of use and gentle non-adherent nature. Two episodes of sharp debridement were carried out during this period. Having completed 48 hyperbaric treatments, Ruby reported that her wound had improved in relation to both pain and importantly the amount of exudate. Dressing changes were less frequent and reliance on pain medication had decreased.

Despite a general overall improvement, Ruby felt that at this point in time there were further options that she could explore and embarked on a consultation with a local medical skin clinic.

Omnilux® and light-emitting diodes

Medical use of light-emitting diodes (LEDs) first occurred in 1988 with a prototype light source that was used as a safe alternative to lasers for photodynamic therapy. Researchers at the National Aeronautics and Space Administration (NASA) discovered that LEDs had many promising medical applications, including wound healing[7].

The Therapeutic Goods Administration (TGA)-approved Omnilux® system comprises an operational base unit with up to three detachable treatment heads. Each individual treatment head delivers a pure, optimised, narrow-band light via a matrix of LEDs carefully positioned to deliver light to the treatment area. The treatment heads are constructed from adjustable planar arrays, which are set to deliver an even irradiance to the target tissue area from a distance of approximately 3 cm (Figure 3).

Figure 3. Ruby undergoing an Omnilux™ treatment.

The medical treatment protocol in wound healing uses two lights: the Revive at 633 nm (visible light) and Plus at 830 nm (near infrared), with a precise, computer-calculated dose delivered to the skin over a 20-minute period. Trials have clearly displayed that 633 nm light enhances not only DNA synthesis, but also augments cellular tissue regeneration pathways including collagen, elastin and ground matrix deposition[8,9]. Study groups have shown that a combination of the 830 nm lights combined with 633 nm lights accelerates the wound healing response and, therefore, offers an effective treatment for the healing of compromised tissue[9-11].

Ruby began a course of Omnilux® treatment in early October 2010. The wound healing protocol used for Ruby involved the use of both the Plus (830 nm) and Revive (633 nm) lights over a five-week period.

Wound healing protocol

Week 1: 3 x 20 minute treatments of the Plus light (830 nm) – given on Monday, Wednesday and Friday.

Week 2: 3 x 20 minute treatments of the Revive light (633 nm) – given on Monday, Wednesday and Friday.

Week 3: 1 x 20 minute treatment of the Plus light (830 nm) – given on Wednesday.

Week 4: 1 x 20 minute treatment of the Plus light (830 nm) – given on Wednesday.

Week 5: 1 x 20 minute treatment of the Plus light (830 nm) – given on Wednesday.

The combined 830 nm/633 nm LED phototherapy regimen appears to control the inflammatory process of a wound and accelerate the degranulation of mast cells[8-10].

Following Ruby's first treatment, she reported her back was pain-free for several hours. By the end of her initial Omnilux® course Ruby was able to drive, was sleeping through the night, able to work in her garden and found she was able to manage many of her activities of daily living – all of which she had previously not been able to achieve.

Ruby went on the have a further two courses of Omnilux® treatments over the next four months. Both these courses were a repeat of the wound healing protocol outlined above. Figure 4 shows Ruby's sacral wound at the completion of her

Figure 4. Ruby's wound at completion of her hyperbaric oxygen course - October 2010.

hyperbaric treatment in October 2010 and Figure 5 shows the wound at completion of her third course of Omnilux® in February 2011. Wound assessment at this time showed clear improvement in the inflammation and irritation. Epithelialisation was evident along with a decrease in the amount of slough and considerable improvement in both exudate volumes and the pain that Ruby was experiencing.

Figure 5. (L) Shows Ruby's wound in October 2010 prior to her first Omnilux™ course and (R) February 2011 following a third course of Omnilux™.

Summary

Ruby represents a young woman with a complicated wound management problem. Her understanding of both her medical condition and the emotional support she required demonstrates clearly how patients are able to cope with and adapt well to what most of us would consider a lengthy and involved wound management situation. It was the high level of pain along with the management of large volumes of exudate that Ruby considered to be the cause of her anxiety and subsequent impingement on her lifestyle. This she felt was the catalyst for her to seek other available treatment options.

As valued health care professionals, nurses must respect the autonomy of patients as they pursue adjunctive avenues that are not necessarily familiar treatment options for management of illness in order to improve their personal wellbeing and health care.

> *"…it has made a huge positive impact on my life. Without your concern and efficiency it would not have been possible to feel so much better and to be able to get on with simple things, like driving longer distances and wearing jeans, which I had previously taken for granted. You have made a difference to my life and I will appreciate it forever"* – Ruby April 2011

Abbreviations

Transverse rectus abdominis myocutaneous (TRAM)
Magnetic resonance imaging scan (MRI)
Transcutaneous oxygen measurements (TCOM)
Atmospheres absolute (ATA)
Light-emitting diodes (LEDs)
National Aeronautics and Space Administration (NASA)
Therapeutic Goods Administration (TGA)

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