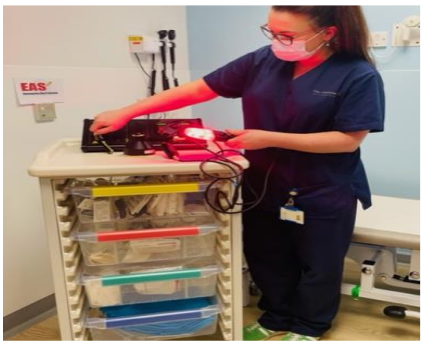
PHOTOBIOMODULATION THERAPY (PBM): USING LIGHT THERAPY FOR ORAL MUCOSITIS, PALLIATIVE CARE TEAM

TEAM MEMBERS: Alexandra Langstaff, Clinical Nurse Specialist, Supportive and Palliative Care



Background:

The Christie NHS Foundation Trust in Manchester is one of the largest cancer treatment centres of its type in Europe. When diagnosed with head and neck cancer, many patients require radical treatment inclusive of both chemotherapy and an extensive course of radiotherapy[1]. Significant early and long-term side effects are not uncommon[2] and may include xerostomia, dysphagia, pain, nausea, fatigue, and speech difficulties[3, 4].

The most problematic of early side effects for patients with a cancer diagnosis involving base of tongue and tonsil cancer is mucositis; inflammation and breakdown of the mucosal lining in the oral cavity / oesophagus[5]. Mucositis can result in severe pain and complications such as lack of nutrition[6] requiring supplemental feeding (e.g. a nasogastric tube). Mucositis also presents a significant risk for infections and sepsis[7].

Patients experiencing significant effects of mucositis often require additional hospital appointments and admissions, sometimes for several days or more. This takes both a physical and psychological toll on the patient, having a major social impact due to limiting engagement in social activities around mealtimes and psychosocial issues due to the embarrassment of the mucositis itself, oral malodour and having a feeding tube visible on the face[8, 9].

During 2018 after consideration of available evidence, The National Institute for Health and Care Excellence (NICE) published interventional procedures guidance recommending the use of Photobiomodulation (PBM) for the prevention or treatment of oral mucositis[10]. There are more than 700 randomised controlled clinical trials available examining PBM for a variety of uses in the medical field[11], with over 50 successful trials alone evaluating PBM in relation to oral mucositis. Since NICE approval, PBM has been recommended as an adjuvant intervention for prevention of oral mucositis for head and neck cancers by Multinational Association of Supportive Care in Cancer (MASCC) and the International Society of Oral Oncology (ISOO).

PBM involves application of light to tissues to promote healing, reduce inflammation and increase cell metabolism[12, 13]. PBM stimulates the natural healing process, in turn reducing pain. Using the correct wavelength to displace mitochondrial nitric oxide (mtNO), oxidative stress is reduced and cellular adenosine triphosphate (ATP) production increases. This process promotes cell metabolism, therefore reducing inflammation and triggers the natural healing process[14].

Within our service, our team want to minimise the negative effects of radiation and improve the quality of life of our head and neck patients. There are approximately 518 patients per year who have radical treatment for a range of head and neck cancers and therefore at high risk of mucositis potentially leading to use of controlled medications, alternative feeding routes and emergency admissions.

As the Supportive and Palliative Care Team manage patients at all different stages of their cancer treatment, PBM was raised as a potential supportive measure that may run alongside cancer treatment.

Specific Aims:

To evaluate the clinical, social, financial and environmental impacts of PBM as a supplemental treatment for the prevention and/or reduction of oral mucositis for base of tongue and tonsil oncology patients undergoing radical radiotherapy +/- chemotherapy.

Methods:

A representative from the equipment supplier, Thor[11], was contacted to arrange a meeting and demonstration. Due to the confidence of the equipment supplier in regard to the beneficial effects of PBM, the equipment was given on loan with no associated costs. Over a period of four months a PBM unit was sourced and trialled in a small cohort of our head and neck patients at The Christie.

A total of twenty-two patients were included in evaluation to evaluate if PBM would be an effective treatment for reducing mucositis symptoms alongside the associated treatments and admissions. There was an equal number of patients in the control and study/treatment group, both of which had a comparable mean age. All patients were undergoing radical radiotherapy +/- chemotherapy for base of tongue or tonsil cancer (due to their high risk of severe mucositis).

Control group: Retrospective patient data was collected from clinic records for 11 patients who had recently completed radical radiotherapy and had their six week follow up appointment. The control group did not receive PBM treatment and were treated for symptoms of mucositis as they presented.

Treatment group: 11 patients were identified from the head and neck new patient clinic who were to receive the same radiotherapy treatment as the control group. This group received PBM treatment alongside their radiotherapy treatment for 30 consecutive days (the common duration or a radiotherapy treatment regime).

Patients received their PBM treatment before each radiotherapy session, therefore no additional journeys were expected to be made by the patient. The first treatment was delivered with support

from myself (Clinical Nurse Specialist), however subsequent treatments were self-administered by the patient. A hand-held probe is used to deliver light to the oral mucosa, both intra and extra-orally (as pictured). Light is applied for a period of one minute per area, and seven areas are treated. The treatment takes approximately 15 minutes of patient time in total, with a direct treatment time of 7 minutes.


Following analysis of our results, our next steps are involve presenting to the Head and Neck team with a plan to implement PBM into the treatment protocol for all within this patient cohort.

Measurement:

Patient outcomes: The following was compared across the control and treatment groups:

- Severity of mucositis symptoms:
  Mucositis is graded using a national grading tool from The Radiation Therapy Oncology Group (RTOG) which scales toxicities such as mucositis and external skin damage (REF). On each day the patient's oral cavity would be examined for any reaction or deterioration and grade on the RTOG scale and document. Additionally, each patient is seen weekly by the Head and Neck team to assess side effects. During this appointment they also grade the level of mucositis, therefore the accuracy of grading was confirmed.
- Frequency and length of unplanned admissions:
  When a patient is admitted documentation is kept on our hospital database, reason for admission is listed. Therefore, I was able to identify admissions related to mucositis. This would also identify if an alternative feeding route (nasogastric tube) was needed or if admission was a mucositis related infection.
- Type and dose of medications required because of mucositis for pain:
  I regularly checked medication use with detail on when initiated, frequency taken and dose. This information is also listed with their weekly Head and Neck team assessment.
  We looked specifically at use or Morphine and Pregabalin
- Any further treatments or interventions required because of mucositis such as nasogastric tube insertion and anti-biotics for infection.

Environmental sustainability:

The number of bed days (from unplanned admissions) and differences in medication start dates and dosages were used to estimate carbon savings from PBM treatment.

CO2e for unplanned admissions was estimated using the 2015 Sustainable Development Unit (SDU) (now Greener NHS) emissions factor for a low intensity ward bed day (37.9 kgCO2e). Additional

emissions for patient travel were also included based on average patient distance taken from the Health Outcomes for Travel Tool (HOTT) and converted into carbon emissions using CSH's patient travel calculator.

CO2e reduction for reduced medications (Morphine, Pregabalin and antibiotics) were estimated using a top-down Environmentally Extended Input Output Analysis (EEIOA). The emissions factor for pharmaceuticals (0.1277 kgCO2e/£) taken from 2021/22 Greener NHS database was used to convert drug cost saving into carbon emissions.

It was not possible to include carbon savings for nasogastric tube insertion and feeds at this stage due to many variables involved and extensive data collection that would be required.

To estimate CO2e from the PBM device and treatment, we calculated the kgCO2e from electricity usage per patient. We did not carbon footprint the device as based on the significant number of uses the CO2e per use would be very small.

Economic sustainability:

A bed day cost of £513 (including all overheads and running costs but no treatment or drugs) was provided by the Christie finance team.

Costings for medication taken from British National Formulary (BNF)[16]. The cheapest cost available was used for medication and therefore may be an underestimation.

The investment cost of one PBM device is £25,000. To provide the service full time to those most at risk of developing mucositis (180 patients/year) 6 devices are required. Therefore, the investment cost for full implementation of this treatment is £150,000 (including servicing and warranty of machines). The lifespan of the device is reported by Thor as a minimum of 10 years.

Social sustainability:

We obtained qualitative data from patients on their experience of using the PBM device.

Results:

Clinical, Environmental and Economic outcomes:

The table on the next page summarises a comparison of the control and treatment patient group outcomes. The clinical data has been translated into financial and CO2e savings.

Patient outcome	Control Group	PBM Treatment Group	Difference in groups	£ saving	CO2e saving
Admissions					
Number of admissions	10	3	7 admissions	£32,319*	2,483.39*
% unplanned	35%	10%	25% reduction		
Length – range	1-33 nights	1-5 nights	NA		
Length - average	7.1 nights	2.6 nights	4.5 days		
Bed days - total	71 days	8 days	63 days		
				*Admission savings based on bed days total and travel reductions	
Medication – Morphine					
number of patients prescribed *Same dosage 4 times daily	11 (100%)	4 (36%)	7 (64%)	£162.40 *for 7 patients saving 4 weeks of medication	20.74
Average week of radiotherapy course medication was prescribed	2.4 weeks	4.3 weeks	1.9 weeks *We have assumed 3 weeks difference due to 7 patients having no morphine	£69.60 *for 4 patients saving 3 weeks of medication	8.89
Number of patients continuing morphine 6 weeks post treatment	55% (6/11)	50% (2/4)		NA - Not included in financial and carbon savings or projections	
Medication - Antibiotics – 7 day course					
Oral – number of patients prescribed	4	0	4	£30.80	3.93 kgCO2e
IV - number of patients prescribed	1	1	No difference	NA	NA
Medication – Pregabalin					
Number of patients prescribed	10	9	1	NA	NA
Average week of radiotherapy course medication was prescribed/ commenced	2.4 weeks into radiotherapy course	4.3 weeks into radiotherapy and PBM course	1.9 weeks *We have assumed 3 weeks difference per patient as 2 patients did not need any treatment in this time	£515	65 kgCO2e

Average dosage	98mg twice daily	65mg twice daily	66mg saving per day per patient	£247.90	31.66 kg CO2e
Number of patients continuing pregabalin 6 weeks post treatment	7 patients	3 patients	50% reduction on patients still needing medication at wk 6	NA - Not included in financial and carbon savings or projections	
Nasogastric tube insertion	4 patients	1 patient	75% reduction	NA – NG equipment and community needs not included in financial and carbon savings or projections	
Total difference				£33,345	2,613.99

Treatment:

For 30 days of treatment, 0.04 kgCO2e is used per patient. Removing this from our savings above, gives a total carbon saving of **2,613.99 kg CO2e per year** based on 11 patients. This is equivalent to 7,528.77 miles driven in an average car.

Based on treatment eligibility to the full 180 tonsil and base of tongue cancer patients per year, having one 30-day course of radiotherapy + PBM a year, our savings will increase to 42,774 kgCO2e per year. This is equivalent to 123,197 miles driven in an average car. However, this is likely an underestimation of savings given additional benefits that were not measured (reduced nasogastric tube and associated equipment, reduced medication courses post treatment).

Economic sustainability:

There is a cost of 5p for electricity per patient treatment course. To treat 180 patients in a year the electricity cost would therefore be £90.00 (based on average UK electricity costs in January 2023)**.** For 6 devices the investment cost is £150,000. Assuming treatment for 180 patients per year and a 10-year lifespan for each device, the treatment cost is therefore £83.35 per patient per year.

The cost for the treatment group was therefore £916.85. Accounting for PBM treatment costs, we have saved **£32,428** in admission and medication costs in our cohort of 11 patients.

Projected to all 180 eligible tonsil and base of tongue cancer patients, our savings have potential to increase to £530,640.36 per year in admission and medication costs. However, a large proportion of this savings is due to reduced inpatient admissions, so this will not be a cash-releasing saving.

Social sustainability:

This intervention requires no extensive training for staff and minimal input from employees due to patient self-administration. There is potential for improved job satisfaction for employees working within this patient cohort as staff will be aware they are reducing incidence of pain and discomfort and improving quality of life for their patients. There is potential to save waiting times for bedspaces by reducing emergency admissions to the hospital for mucositis related issues (pain, feeding, infection).

For patients, the device is easy to use, non-invasive and only takes a few minutes each treatment so it does not add significant time spent within the hospital or alter treatment completion dates. Successful treatment will improve ability to engage in social life, such as mealtimes with family and friends.

Patients felt involved in their treatment and reported they felt 'empowered' and in control in a time where loss of control has been felt throughout.

> *"It was easy to use and I would recommend it to others undergoing head and neck radiation"*
>
> *"One doctor did remark that I was better than he expected at this stage"*
>
> *"The treatment itself was fine - not intrusive or complicated just very easy and quick to complete the daily procedure. I am assuming this treatment has been very beneficial because I did not suffer from most of the really bad side effects from radiotherapy that the doctors thought I might"*
>
> *"I hope everyone can now benefit from this treatment and would thoroughly recommend it. Also it was very mentally reassuring to think that I am benefitting from some new state of the art technology.."*

Patients did not need to attend hospital more frequently as their treatment took place after their radiotherapy session. However, we were unable to deliver treatment in the radiotherapy department and patients had to attend a different area of the hospital for PBM. This was more challenging for patients, in particular those who had reduced mobility, and was raised by patients in the evaluation.

Discussion:

This small study demonstrates that implementation of PBM treatment has great potential to offer benefits across the triple bottom line of sustainable value while improving our patient care. There are many benefits that were not directly measured, and we therefore anticipate the savings from the implementation of PBM into treatment protocols are significantly underestimated.

Additional costs may include cost of imaging associated with nasogastric tube positioning, cost of training to use feeding equipment and cost of dietetics support in the community. Patients may also continue medications included within the study for an extended period of time which was not captured within our current study. Patients may have many more unplanned admissions which require additional appointments with the head and neck team in which consultant input is required.

Limitations

- Patient evaluation was not anonymous which could potentially bias patients' responses regarding their treatment.
- Size of sample and length of evaluation: Evaluation could be extended to capture a larger sample and longer time post treatment, again benefits could be underestimated as many continue to experience effects of mucositis beyond 30-day treatment period.

- We did not carbon footprint the PBM device itself. To do a full bottom-up process based analysis we would need significant information from the company which would be very time consuming, and using financial cost would be inaccurate.

Barriers / challenges encountered

- Potential risks: There are no reported side effects in history of PBM according to suppliers. However, as there are options for both flashing and static light for PBM delivery, to prevent exacerbation of existing comorbidities such as migraine/epilepsy, treatment was delivered for all patients on the static setting.
- To provide further protection, protective glasses that eliminate LED light were also offered to patients. This worked well for a patient with a history of migraines.
- Other patients in head and neck cohort had heard about treatment via word of mouth. This was challenging as a practitioner unable to offer to others despite awareness of their side effects.

Other settings:

PBM treatment is applicable to patient cohorts beyond tonsil and base of tongue. It can support breast cancer-related lymphoma where post treatment patient's experience pain, tightness and heaviness and lymphedema; for radiation fibrosis syndrome; and for Haematopoietic stem cell transplantation (HSCT) in both paediatric and adult populations.

Conclusions:

The study of patients PBM confirmed findings highlighted within NICE guidelines, beneficial effects were evident and revealed improvements to patient side effects, reduced admissions, reduced medication use and a quicker recovery (highlighted by discontinuation of analgesic medication. All of these factors show a knock-on effect to achieving NHS net zero targets with significant reductions in cost and carbon emissions. The supplier who provide PBM equipment were unaware of the clear environmental benefit of the product and how this will affect marketability for them by meeting NHS net zero agenda.

We are now in discussion with the head and neck team to incorporate PBM into treatment protocols for this patient group. Completion of a business case to purchase machines to deliver PBM on radiotherapy dept pre-treatment is underway. Post purchase, we will evaluate patients using PBM for a period of 1 year to assess effect with a large patient sample. We also aim to liaise with a number of NHS trusts, to disseminate sustainability information and demonstrate the 'green' element of this treatment.

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