Hyperbaric oxygen therapy for late onset dropped head syndrome following mantle field radiation therapy for Hodgkin lymphoma: a case report and literature review

Shane A Rosenzweig[1,2], Stephen R Thompson[3,4], Michael H Bennett[4,5]

[1] *Department of Radiation Oncology, Crown Princess Mary Cancer Centre, Westmead Hospital, Sydney, Australia*
[2] *Central Clinical School, University of Sydney, Sydney, Australia*
[3] *Department of Radiation Oncology, Prince of Wales Hospital, Sydney, Australia*
[4] *Prince of Wales Clinical School, Faculty of Medicine, University of New South Wales, Sydney, Australia*
[5] *Department of Diving and Hyperbaric Medicine, Prince of Wales Hospital, Sydney, Australia*

Corresponding author: *Dr Shane A Rosenzweig, Crown Princess Mary Cancer Centre, 166-174 Hawkesbury Rd, Westmead, NSW 2145, Australia*
ORCiD: *0009-0007-1891-5339*
shane.rosenzweig@health.nsw.gov.au

Keywords
Case reports; Malignancy; Musculo-skeletal; Radiotherapy; Treatment sequelae

Abstract

(Rozenzweig SA, Thompson SR, Bennett MH. Hyperbaric oxygen therapy for late onset dropped head syndrome following mantle field radiation therapy for Hodgkin lymphoma: a case report and literature review. Diving and Hyperbaric Medicine. 2025 30 September;55(3):275–279. doi: 10.28920/dhm55.3.275-279. PMID: 40986924.)
The authors present the first documented case of the apparent effective use of hyperbaric oxygen therapy (HBOT) for the treatment of radiation-induced dropped head syndrome (DHS). DHS is a condition associated with progressive and often severe weakness of cervical paraspinal muscles, especially the neck extensors. This results in loss of horizontal gaze and in advanced cases causes a chin-on-chest deformity. Radiation-induced DHS is a rare, primarily late-term complication first described in patients treated with mantle field radiotherapy for Hodgkin lymphoma, though there is an increasing body of literature demonstrating a wide range of presentations. A 59-year-old man with a history of stage 2A Hodgkin lymphoma 34 years prior had been treated with extended field radiotherapy, including mantle radiotherapy, totalling 40 Gy in 19 fractions. He presented with three years of progressive neck extension weakness with associated stiffness and intermittent dysphagia. The patient underwent 60 sessions of HBOT, in conjunction with physiotherapy and thiamine replacement and demonstrated improvement of his postural maintenance and dysphagia. His improved function was maintained at three years follow-up. We discuss the literature on the management of this rare condition, including the rationale for using HBOT which is well documented for the treatment of other late-term radiotherapy side effects. This case adds to the increasing literature on the management of DHS and describes a novel approach to the management of this often-debilitating condition.

Introduction

Dropped head syndrome (DHS) is a condition associated with progressive and often severe weakness of cervical paraspinal muscles, especially the neck extensors. This results in the mechanical inability to maintain horizontal gaze and in advanced cases causes a chin-on-chest deformity.[1] DHS is a known complication of a variety of conditions including; inflammatory myopathy, amyotrophic lateral sclerosis, Cushing's syndrome, myasthenia gravis and ankylosing spondylitis.[2] Its relation to radiotherapy was first described by Johansson et al.,[3] in the setting of mantle field radiation therapy (RT) for Hodgkin lymphoma (HL).

Previously, the standard of care for HL involving cervical or mediastinal lymph nodes was extended field RT (including mantle field RT) or, more recently, chemotherapy and mantle field RT. Mantle field RT consists of fields encompassing the submandibular, cervical, supraclavicular, infraclavicular, axillary, mediastinal, subcarinal and hilar lymph nodes.[4] Although the use of mantle field RT has been radically reduced with the introduction of more modern techniques and combination chemotherapy protocols, there are many surviving patients who underwent this treatment.[5] As of 2009, 1,415 HL survivors were treated with mantle field RT between 1965 and 1995 in the Netherlands alone.[6] In the first of its kind, a recent study of childhood survivors who received radiotherapy to the neck for HL and other malignancies demonstrated five out of 41 (12%) patients had DHS.[7]

Whilst DHS was first reported in HL survivors, likely due to their good oncological outcomes, radiation-induced DHS is primarily associated with high-dose RT to the head, neck

and upper chest.[5,7,8] This is demonstrated with increasing recognition of early and late onset DHS in head and neck cancers,[9–14] indicating that it is likely a radiation effect rather than a tumour-specific pathogenesis.

Despite this increasing body of literature, DHS remains a rare condition and there is no consensus on the appropriate management.[15] Here we describe a case of DHS with a sustained positive outcome following treatment with hyperbaric oxygen therapy (HBOT) in combination with physiotherapy and thiamine replacement. To the best of our knowledge this is the only documented case of the use of HBOT.

Case report

The patient provided written consent for reporting of his case details.

A 59-year-old male presented with a three-year history of neck extension weakness with associated stiffness and intermittent dysphagia described as choking on foods once per month. He reported no lower limb difficulties. Examination revealed a hoarse voice, and his head was dropped in flexion to 45 degrees. There was wasting of the neck and proximal shoulder muscles bilaterally, with reduced proximal power. All reflexes were symmetrical, and coordination was normal. There was preserved proprioception and a mild cape-like sensory loss over the chest and upper back – though this was only elicited by one of the two neurologists that were consulted. Examination of the lower limbs was normal.

He had a history of stage 2A HL 34 years prior, and had been treated with extended field RT, including mantle field RT, without chemotherapy, totalling 40 Gy in 19 fractions (including a single sequential boost to the mediastinum), by parallel opposed 6 MV anterior-posterior (AP)/posterior-anterior (PA) photon fields (with AP and PA fields given on alternate days). Cervical spinal cord dose exposure was retrospectively estimated at 42 Gy ($\alpha/\beta = 2$). Following treatment, the patient experienced self-limiting subacute L'Hermitte's syndrome, but otherwise recovered well.

Magnetic resonance imaging (MRI) of the spine showed mild disc degenerative change at C4/5 and C5/6, with no other abnormalities. A dedicated MRI of the neck and shoulder girdle was not conducted. Nerve conduction studies demonstrated a generalised sensory neuropathy of axonal type, with motor studies within normal limits. Limited electromyography (EMG) was undertaken given concurrent warfarin prescription, but did not demonstrate evidence of neurogenic change within the muscles. In light of the presentation and findings, a diagnosis of DHS, due to radiation myelopathy, was made.

An initial trial of prednisolone was commenced six weeks after presentation, starting at 25 mg twice daily for three days and then weaned over 12 days. This resulted in an improvement in subjective well-being but without improvement in strength. The patient had not previously undergone physiotherapy and was noted to consume 40 g of alcohol per day. He was commenced on a regimen of physiotherapy and thiamine replacement. Given the evidence of HBOT in the treatment of other late radiation sequelae and incomplete improvement of symptoms with prednisolone, he was also referred to the Diving and Hyperbaric Medicine Department and completed a course of 40 HBOT treatments. A month later this had led to a significant improvement in postural maintenance, thereafter, reducing over the following three months, although not to pre-treatment levels. He completed a further 20 HBOT treatments seven months later, to further benefit. Six months following completion of HBOT, improvement was maintained, with the patient being able to maintain neck extension for prolonged periods. Examination revealed strength 4+/5. He described improved function, and resolution of dysphagia. He had remained on thiamine replacement and continued physiotherapy. Nearly three years later he had maintained improvement in neck strength and resultant function.

Discussion

Radiation-induced DHS remains a very rare complication of not only HL survivors treated with mantle field RT but also patients who received radiotherapy for lung and head and neck cancers. Radiation-induced DHS has now been described as having a bimodal presentation of early and late onset – with likely differing pathophysiology.

A small series[12] presented four patients with early-onset DHS who had received concurrent radiotherapy and chemotherapy for head and neck squamous cell carcinoma and developed DHS within six months. The authors proposed that the mechanism of this neurotoxicity is secondary to a combination of inflammation, reactive oxygen damage, and mitochondrial dysfunction resulting in apoptotic cell death at a neuronal level.[12] Others have proposed that there is an autoimmune response to the resultant inflammation and that early-onset is usually self-limiting and responsive to corticosteroid treatment.[9] The role of chemotherapy in DHS is difficult to elucidate, to date, DHS has not been linked to chemotherapy alone, though there may be a synergistic effect with radiation.[4,13]

Late-onset DHS can have a latency of over 30 years, as discussed in the case presented. Despite the increasing body of literature there remains no consensus on the appropriate management of late-onset DHS.[15] Likewise, the mechanism of late-onset radiation-induced DHS is unclear, some findings have been consistent with primary damage to neurons and others have shown primary or secondary damage to muscles.[5,9] Experimental results have showed that the majority of muscles within the previous radiation field have demonstrated mostly myogenic damage whereas muscles outside of the field showed mostly neurogenic

damage. It has been proposed that muscle damage beyond the RT fields was secondary to neurogenic damage of upstream nerve roots and/or of the brachial plexus which were situated within the radiation field.[5,9,16]

It is well known, and not exclusively linked to DHS, that endothelial cells and vascular smooth muscles are susceptible to radiation damage and thus, it is hypothesised that myogenic damage may be due to extrinsic factors such as progressive microvascular fibrosis.[5,13]

Given the complexity, prolonged latency, and rarity, it can be difficult to diagnose DHS and provide a comprehensive evidence-based management plan. In the first instance, assessment and exclusion of any other underlying conditions that can cause DHS should be thoroughly undertaken. We briefly review the literature to discuss conservative and surgical management, prevention and screening, and discuss the rationale behind hyperbaric oxygen therapy.

CURRENT MANAGEMENT

Conservative management has remained the mainstay of treatment for DHS, though this demonstrates mixed efficacy in case reports and there is no consensus on optimal management. In case reports of late-onset DHS, intensive rehabilitation has been shown to stabilise,[17] or gradually improve symptoms, though not back to baseline.[8]

Surgery has been proposed as a second-line treatment in patients who have failed conservative treatment or who have refractory symptoms.[18] Surgical options include pre-operative spinal traction, posterior fusions, anterior/posterior fusion or multi-level osteotomies. In a small case series[14] of seven patients with radiation induced DHS, surgery demonstrated significant improvement in both clinical and radiological outcomes. However, it was associated with high peri-operative complications, such as pneumonia and respiratory distress requiring temporary reintubation. These were short-lived and overall, the patient reported long-term outcomes remained satisfactory.[14]

A systematic review[15] including 129 patients assessing all causes of DHS demonstrated that for the 14 patients that underwent surgery alone, 93% had positive outcomes. The rate of positive outcomes reduced to 73–88% with combinations of medical and immunosuppressive treatments and significantly reduced to 18% with bracing or physiotherapy alone.[15] The importance of a multi-modal approach is reflected in our case report, where a combination of physiotherapy, thiamine replacement and HBOT provided a meaningful improvement in the patient's symptoms.

PREVENTION AND SCREENING

There appears to be a clear association between dose of radiation the extensor muscles receive and incidence of DHS. In their review[10] of early-onset DHS in head and neck cancer, Inaba et al., discussed three patients with DHS who had mean neck extensor muscle dose of 42.3 Gy, 58.5 Gy and 60.9 Gy compared with nine control patients who received less than 50 Gy. This study also compared the dose-volume histogram which revealed that V_{60Gy} (the volume receiving 60 Gy) and V_{70Gy} (the volume receiving 70 Gy) were significantly greater in the patients with DHS compared to those without DHS. The mean value for V_{60Gy} and V_{70Gy} in patients with DHS was 32.7% and 7.0% respectively and 5.7% and 0.5% in patients without DHS. Thus a dose constraint of less than 46 Gy–50 Gy was proposed.[10] However, given the rare nature of DHS and insufficient evidence, this dose constraint should not impede the adequate dosage and local control of the primary malignancy.

Screening and early intervention can reduce the morbidity of DHS. Rieken et al.,[7] in their recent systematic review, proposed a diagnostic algorithm for radiation-induced DHS which focused on a detailed history and clinical examination including; measurements of neck circumference, detailed neurological examination and patient reported questionnaires to assess for cervical muscle atrophy. In their algorithm EMG and muscle biopsy were not routinely included given the often-conflicting results. A biopsy was undertaken as 'ultima ratio' for unresolved cases. They also indicated that MRI scans did not reveal additional information in their study however recommended further evaluation in larger cohorts. It was advised that a focused history and clinical examination were sufficient to diagnose radiation-induced DHS. They went on to recommend the integration of diagnostic algorithms to facilitate prompt diagnosis and intervention as part of comprehensive long-term follow-up care of childhood cancer survivors.[7] This algorithm lays the foundation for recognition of DHS, but work must be done in devising consensus guidelines for the management of DHS.

HYPERBARIC OXYGEN THERAPY

A small case series by van Leeuwen-Segarceanu et al.,[5] presented 12 HL survivors who underwent mantle field RT. Examination revealed ten patients with neck weakness, of which two patients had severe neck weakness resulting in DHS. The remaining two patients did not have neck weakness and it was noted that they performed sports with high neck activation. The authors proposed that neck muscle weakness was secondary to primary vascular injury which led to myogenic damage of the muscles in-field. Thus, treating DHS with intensive rehabilitation may promote increased vascularisation by formation of collateral vessels which may contribute to maintaining muscle strength.[5] This hypothesis can be extended to the use of HBOT.

HBOT is often given at pressures of 2.0–2.5 absolute atmospheres for periods up to 120 minutes daily for a total of 30–60 sessions. HBOT causes a series of physiological effects through increasing plasma oxygen transport and increasing tissue oxygen availability. Subsequently, a high oxygen gradient influences angiogenesis and stimulates

microvascularisation and neocollagenisation leading to the induction of tissue repair. The oxygen tension of irradiated tissues recovers over the course of treatment and is maintained for a minimum of three years without the continued need for HBOT.[19]

Serious radiation complications have been documented in 5% of all patients receiving RT and HBOT has been used as a safe and effective treatment for some radiation-induced tissue injuries.[19] Whilst there are few randomised controlled trials, retrospective data shows that there is statistically significant improvement seen in xerostomia, osteoradionecrosis of the mandible, osteoradionecrosis prophylaxis, soft tissue necrosis and radiation proctitis or cystitis.[20] It has also been showed that the majority of these cases had sustained improvement through a medium follow-up of 3.8 years.[21]

A prolonged beneficial effect was associated with HBOT in the case presented, whereby he had improved neck strength and function at nearly three years follow up.

Conclusions

Prognosis of DHS remains poor and there are no guidelines on the management of this often-debilitating condition. It is crucial that clinicians become aware of DHS as both a rare early and late-term sequalae of RT. Diagnostic algorithms, dose constraints, conservative and operative management have been discussed in the literature. HBOT has proven beneficial in other late adverse effects of RT[22] and is well established for inducing angiogenesis and neocollagenisation which are essential for myogenic recovery. Exclusion of other causes, conservative management and optimisation of medical co-morbidities play important roles in the management of DHS. Though we cannot fully evaluate the efficacy of HBOT in a single case, HBOT in combination with physiotherapy and thiamine replacement, when necessary, may offer an alternative in refractory cases and may be more efficacious than conservative and medical management. More work is required in this field to fully ascertain the effects of HBOT in DHS and efforts are required to propose and evaluate guidelines on the management of radiation-induced DHS.

References

1 Robert M, Lessard LER, Bouhour F, Petiot P, Fenouil T, Svahn J, et al. Inaugural dropped head syndrome and camptocormia in inflammatory myopathies: a retrospective study. Rheumatology (Oxford). 2024;63:506–15. doi: 10.1093/rheumatology/kead347. PMID: 37462538. PMCID: PMC10837000.

2 Luo JJ. Isolated head drop triggered by neck surgery following concomitant chemoradiotherapy. J Clin Neuromuscul Dis. 2008;9:348–51. doi: 10.1097/CND.0b013e3181629396. PMID: 18344717.

3 Johansson AS, Erlanson M, Lenner P, Lindh J, Osterman B. Late side-effects are common after treatment of Hodgkin's disease. Muscular atrophy following radiotherapy is a neglected risk. Lakartidningen. 1998;95:44–7. PMID: 9458645.

4 Grimm S, Chamberlain M. Hodgkin's lymphoma: a review of neurologic complications. Adv Hematol. 2011;2011:624578. doi: 10.1155/2011/624578. PMID: 20975772. PMCID: PMC2957132.

5 van Leeuwen-Segarceanu E, Dorresteijn L, Pillen S, Biesma D, Vogels O, van Alfen N. Progressive muscle atrophy and weakness after treatment by mantle field radiotherapy in Hodgkin lymphoma survivors. Int J Radiat Oncol Biol Phys. 2012;82:612–8. doi: 10.1016/j.ijrobp.2010.11.064. PMID: 21288655.

6 De Bruin ML, Dorresteijn LD, van't Veer MB, Krol AD, van der Pal HJ, Kappelle AC, et al. Increased risk of stroke and transient ischemic attack in 5-year survivors of Hodgkin lymphoma. J Natl Cancer Inst. 2009;101:928–37. doi: 10.1093/jnci/djp147. PMID: 19535773.

7 Rieken S, Kronziel LL, Langer T, Rades D, Boppel T, Trillenberg P, et al. Proposal of a diagnostic algorithm for radiation-induced dropped head syndrome in long-term childhood cancer survivors based on a prospective study in a specialized clinical setting and a review of the literature. J Cancer Res Clin Oncol. 2023;149:17865–79. doi: 10.1007/s00432-023-05480-w. PMID: 37947868. PMCID: PMC10725355.

8 Ochi N, Yamane H, Honda Y, Takigawa N. Dropped head syndrome following mantle radiation therapy. Intern Med. 2016;55:421–2. doi: 10.2169/internalmedicine.55.5579. PMID: 26875972.

9 Shields LB, Iyer VG, Liang J, Zhang YP, Shields CB. Early-onset dropped head syndrome and person-in-the-barrel syndrome after radiation therapy: Clinical, electromyographic, and MRI findings. Cureus. 2022;14(8):e28279. doi: 10.7759/cureus.28279. PMID: 36158382. PMCID: PMC9492447.

10 Inaba K, Nakamura S, Okamoto H, Kashihara T, Kobayashi K, Harada K, et al. Early-onset dropped head syndrome after radiotherapy for head and neck cancer: dose constraints for neck extensor muscles. J Radiat Res. 2015;57:169–73. doi: 10.1093/jrr/rrv055. PMID: 26684338. PMCID: PMC4795943.

11 Inoue R, Sawamura M, Yoshimura M, Takahashi R. Dropped head syndrome due to chemoradiotherapy for nasal lymphoma, characterised by short tau inversion recovery high signal intensity in the cervical paraspinal muscles. BMJ Case Rep. 2022;15(11):e252446. doi: 10.1136/bcr-2022-252446. PMID: 36368727. PMCID: PMC9660595.

12 Smillie I, Ellul D, Townsley R, James A, Clark B, Petty RK, et al. Head drop syndrome secondary to multimodality treatments for head and neck cancer. Laryngoscope. 2013;123:938–41. doi: 10.1002/lary.23857. PMID: 23404786.

13 Hashimoto Y, Maebayashi K, Izumi S, Motegi A, Mitsuhashi N. Dropped head syndrome induced by chemoradiotherapy for nasopharyngeal carcinoma: A case report. Jpn J Clin Oncol. 2012;42:1091–3. doi: 10.1093/jjco/hys135. PMID: 22914321.

14 Verla T, Vedantam A, North RY, Xu DS, Raber MR, Fuentes A, et al. Surgical management of postradiation, dropped head spinal deformity in patients with head and neck cancer. World Neurosurg. 2021;156:e1–e8. doi: 10.1016/j.wneu.2021.07.001. PMID: 34245881.

15 Drain JP, Virk SS, Jain N, Yu E. Dropped head syndrome: A systematic review. Clin Spine Surg. 2019;32:423–9. doi: 10.1097/bsd.0000000000000811. PMID: 30844858.

16 Ando J, Ueno Y, Yasuda H, Ando M, Edahiro Y, Honda T, et al. Radiation-induced myopathy developing in a

Hodgkin Lymphoma patient: an autopsy case with systemic muscle sampling. Case Rep Oncol. 2021;14:338–42. doi: 10.1159/000512070. PMID: 33776726. PMCID: PMC7983573.

17 Di Stefano V, Attanasi C, Ferrante C, Di Muzio A. Late onset of dropped head syndrome following mantle radiation therapy for Hodgkin lymphoma. BMJ Case Rep. 2018;11(1):e226822. doi: 10.1136/bcr-2018-226822. PMID: 30567263. PMCID: PMC6301549.

18 Brodell JD, Sulovari A, Bernstein DN, Mongiovi PC, Ciafaloni E, Rubery PT, et al. Dropped head syndrome: an update on etiology and surgical management. JBJS Rev. 2020;8:e0068–e. doi: 10.2106/JBJS.RVW.19.00068. PMID: 32105239.

19 Fernández E, Morillo V, Salvador M, Santafé A, Beato I, Rodríguez M, et al. Hyperbaric oxygen and radiation therapy: a review. Clin Transl Oncol. 2021;23:1047–53. doi: 10.1007/s12094-020-02513-5. PMID: 33206332.

20 Lin ZC, Bennett MH, Hawkins GC, Azzopardi CP, Feldmeier J, Smee R, et al. Hyperbaric oxygen therapy for late radiation tissue injury. Cochrane Database of Syst Rev. 2023(8):CD005005. doi: 10.1002/14651858.CD005005.pub5. PMID: 37585677.

21 Tahir ARM, Westhuyzen J, Dass J, Collins MK, Webb R, Hewitt S, et al. Hyperbaric oxygen therapy for chronic radiation-induced tissue injuries: Australasia's largest study. Asia Pac J Clin Oncol. 2015;11:68–77. doi: 10.1111/ajco.12289. PMID: 25382755.

22 Oscarsson N, Rosén A, Müller B, Koskela LR, Giglio D, Kjellberg A, et al. Radiation-induced cystitis treated with hyperbaric oxygen therapy (RICH-ART): long-term follow-up of a randomised controlled, phase 2-3 trial. EClinicalMedicine. 2025;83:103214. doi: 10.1016/j.eclinm.2025.103214. PMID: 40291346. PMCID: PMC12033922.

Acknowledgements

The late Professor Michael H Bennett AM is included in the authorship for his significant contributions to the clinical care and management of this case prior to his passing. His dedication to patient care and clinical excellence is remembered with deep respect.

Conflicts of interest and funding: nil

Submitted: 6 March 2025
Accepted after revision: 5 July 2025