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Review Article

The impact of red blood cell transfusion on mortality and treatment efficacy in patients treated with radiation: A systematic review

Max Deschner [a,*], Lakshman Vasanthamohan [b], Sondos Zayed [c], Alejandro Lazo-Langner [d,e], David Palma [c], David D'Souza [c], Syed Omar Gilani [a], R. Gabriel Boldt [f], Ziad Solh [d,g]

[a] Department of Medicine, Western University, London, ON, Canada
[b] Department of Oncology, Lakeridge Health, Oshawa, ON, Canada
[c] Department of Radiation Oncology, Western University, London, ON, Canada
[d] Department of Medicine, Division of Hematology, Western University, London, ON, Canada
[e] Department of Epidemiology and Biostatistics, Western University, London, ON, Canada
[f] London Health Sciences Centre, London, ON, Canada
[g] Department of Pathology & Laboratory Medicine, Western University, London, ON, Canada

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ABSTRACT

Introduction: Packed red blood cell (RBC) transfusion is frequently used in patients undergoing radiotherapy (RT) because retrospective data suggest that anemic patients may respond sub-optimally to RT. No high-quality evidence currently exists to guide transfusion practices and establish hemoglobin (Hb) transfusion thresholds for this patient population, and practice varies significantly across centers. This systematic review investigated whether maintaining higher Hb via transfusion in radiation oncology patients leads to improved outcomes.
Methods: We performed a literature search of studies comparing RBC transfusion thresholds in radiation oncology patients. Included studies assessed patients receiving RT for malignancy of any diagnosis or stage. Excluded studies did not evaluate Hb or transfusion as an intervention or outcome. The primary outcome was overall survival. Secondary outcomes included locoregional control, number of transfusions and adverse events.
Results: One study met inclusion criteria. The study pooled results from two randomized controlled trials that stratified anemic patients with head and neck squamous cell carcinoma to RBC transfusion versus no transfusion. The study found no significant differences in overall survival or locoregional control after five years, despite increased Hb levels in the transfused group. We conducted a narrative review by extracting data from 10 non-comparative studies involving transfusion in patients receiving RT. Results demonstrated no consistent conclusions regarding whether transfusions improve or worsen outcomes.
Conclusions: There is a lack of data on the effects of RBC transfusion on outcomes in patients undergoing RT. Well-designed prospective studies are needed in this area.

Introduction

Packed red blood cell (RBC) transfusion is frequently used in patients undergoing radiotherapy (RT) because retrospective data suggest that anemic patients may respond sub-optimally to RT [1,2]. No high-quality evidence currently exists to guide transfusion practices and establish hemoglobin (Hb) transfusion thresholds for this patient population, and practice varies significantly across centers.

Because a restrictive transfusion strategy may balance the benefits of treating anemia with the complications of transfusion, it is used for most hospitalized patients to maintain a Hb above 7.0–9.0 g/dL based on evidence of non-inferiority compared to liberal transfusion thresholds in various settings [3–6]. Evidence is not as clear with regards to optimal transfusion thresholds for patients with cancer treated with RT, including those thought to have a unique biology like cervical cancer. Most oncology patients who require transfusion are transfused at restrictive Hb thresholds using data extrapolated from non-RT settings in order to maximize benefit in life-threatening severe anemia while avoiding adverse effects of excessive transfusion [7]. There is no accepted standard for outpatients with malignancy treated with RT. Based on basic science and animal studies, it is hypothesized that higher Hb levels (e.g., 10.0 g/dL) are needed for cervical cancer patients

* Corresponding author at: Victoria Hospital, 800 Commissioners Road East, Rm. E6-117, London, Ontario N6A 5A5, Canada.
E-mail address: max.deschner@lhsc.on.ca (M. Deschner).

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receiving RT to avoid hypoxia-induced radio-resistance [1,2]. Enhanced tissue oxygenation helps form reactive oxygen species that optimize cancer cell death, whereas anemia may lead to increased tumour hypoxia associated with radio-resistance from decreased tumour oxygenation. Tumour hypoxia has been associated with angiogenesis, resistance to apoptosis and possible resistance to cytotoxic therapies [2,8,9]. Low pre-treatment Hb levels have been associated with both reduced locoregional control and survival in head and neck malignancies [10]. It is not known if overall survival outcomes and local tumor control following RT are causally related to anemia or the transfusion strategy.

To our knowledge, no standard Hb transfusion thresholds have been established for patients with malignancies treated with radiation. We conducted a systematic review aiming to investigate whether maintaining higher Hb levels using RBC transfusions in patients receiving RT improves outcomes.

Methods

Eligibility criteria, literature search and study selection

A systematic literature search was conducted to identify randomized controlled trials (RCTs), cohort studies, case reports and case series (20 or more patients) comparing Hb transfusion thresholds in adult and pediatric radiation oncology patient populations, adhering to

standards of the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement. Included studies needed to compare a group transfused at a standard (restrictive) Hb threshold and a group transfused at a higher Hb level (liberal). Studies could include treatment with erythropoiesis-stimulating agents. Studies were excluded if they provided no comparison between different transfusion thresholds, were not related to RT or assessed chronic transfusions for non-malignant indications (e.g., thalassemia).

We performed a literature search of PubMed, EMBASE and the Cochrane Library for citations from database inception until January 2019. Reference lists from retrieved titles were hand searched. Studies were restricted to those published in English, French and Spanish. The full search strategy is found in **Appendix 1**.

Screening of titles and abstracts for eligibility was done independently by two reviewers (MD and SZ) in duplicate. Full text screening of potentially eligible articles was also completed by the two reviewers independently in duplicate. Conflicts were managed by consensus after consultation with a third reviewer (LV). For data from a study published in multiple publications, the most complete source of data was used. Data were extracted independently by four authors in duplicate (MD, SZ, LV and SG). Baseline patient characteristics were noted including the type and stage of cancer, the modality of radiation and the exposure to chemotherapy.

Outcomes

The primary outcome of interest was overall survival. Secondary outcomes included number of RBC transfusions, Hb/hematocrit levels, locoregional disease control, cancer-related mortality, time to next anti-cancer therapy, cardiovascular events, transfusion-related adverse events, radiation-induced adverse events, and quality of life measurements. Initially, we sought to perform a *meta*-analysis of RCTs, however upon initial scrutiny there was a lack of RCTs, so the protocol was modified to include observational studies.

Results

Our primary literature search yielded a total of 6455 eligible titles from three databases (PubMed = 4585, EMBASE = 1256; Cochrane Library = 614). After eliminating duplicates, we considered 6172 articles for screening. After screening titles and abstracts, 39 studies were eligible for full-text analysis (Fig. 1). Of the 39 studies eligible for this

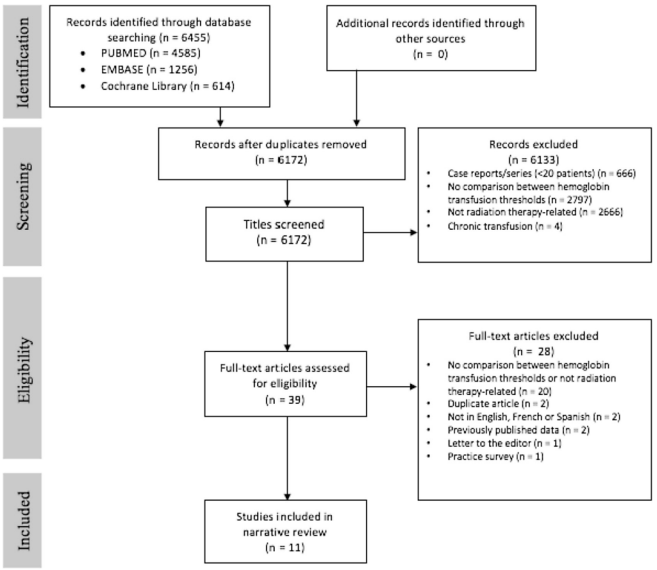

Fig. 1. PRISMA flowchart of article selection process.

systematic review, 20 were excluded as they did not directly compare different transfusion thresholds in oncology patients undergoing RT. Eight other studies were excluded as they presented duplicate data (n = 2), were not presented in English, French or Spanish (n = 2), presented previously published data (n = 2) or were articles in excluded formats. Only one article met pre-specified inclusion criteria, so a *meta*-analysis was not performed. We extracted data from 10 other non-comparative studies involving transfusion in patients receiving radiation to conduct a narrative review of the available literature. Results are presented as descriptive findings. The extracted studies (Table 1) involved a variety of malignancies, populations, sample sizes, settings and time frames and were primarily single-center retrospective studies assessing outcomes of local transfusion policies.

The sole study meeting our inclusion criteria pooled results from two Danish RCTs (DAHANCA 5 and 7) that stratified 1200 patients with head and neck squamous cell carcinoma (HNSCC) with low pre-radiation Hb levels (females < 13.0 g/dL and males < 14.5 g/dL) to RBC transfusion (235 patients) versus no transfusion (230 patients) [11]. The trials were designed to assess the role of a radio-sensitizing drug (DAHANCA 5) and accelerated fractionation RT (DAHANCA 7), but both trials evaluated the effect of transfusion on anemic patients as a parallel intervention. The primary outcomes were locoregional control after RT, disease-specific survival and overall survival. Results were pooled from the two RCTs. Patients with low Hb had reduced loco-regional disease control (HR 0.83, CI 0.70–0.98, p = 0.03) and overall survival (HR 0.77, CI 0.67–0.89, p = 0.0004) compared to the normal Hb group. There was no difference in loco-regional control (HR 1.06, CI 0.82–1.38, p = 0.7), disease-specific survival (HR 1.27; CI 0.97–1.65; p = 0.1) or overall survival (HR 1.24, CI 0.99–1.54, p = 0.08) in patients who were transfused versus those who were not. In multivariate analyses, low Hb was associated with a reduced overall survival compared to normal Hb (HR 0.85, CI 0.73–0.99, p = 0.04) irrespective of transfusion protocol.

Results from studies of patients with cervical cancer were assessed. One Canadian study found patients with higher Hb levels (> 12 g/dL) had improved overall survival (p < 0.0001) [12]. Anemia during RT was found to be an independent predictor of poor outcomes in multivariate analysis (p < 0.0001). Patients who had Hb > 12 g/dL at the completion of radiation had better outcomes than those with a Hb < 12 g/dL regardless of transfusion requirements. The authors concluded that transfusion may overcome the negative prognostic effects of anemia [12]. Negative effects of anemia on mortality and local disease control were found in a review of 204 Austrian cervical cancer patients

Table 1
Qualitative summary of studies included in the narrative review.

Author, year, country	Study design	Setting, participants	Sample size, n	Age, years	Follow up, months	Outcome assessed	What was studied	Major findings	Comment
Girinski et al., 1988, France	Retrospective review	Patients with advanced cervical carcinomas (Stage IIB or III) treated with RT	386	57.7 (mean)	Not reported	Local regional and distant failure	Reviewed effect of Hb level (threshold of 10.0 g/dL) and transfusions in subgroup analyses before or during RT on locoregional or distant failures	Hb levels only prognostic during RT; patients with at least one Hb < 10.0 g/dL had a higher risk of locoregional failure; suggested transfusion may be beneficial if given before RT, but not during treatment	
[20], UK	Retrospective review	Patients undergoing TURP with high dose RT for prostate carcinoma	71	66 (median)	Not reported	Total and local recurrence 5-year survival	Reviewed effect of transfusion in patients who have received RT after TURP	5 year survival in transfused group was 17% and in non-transfused group was 66%, suggesting that perioperative transfusion post-RT may be associated with worse survival and increased recurrence (but not local recurrence)	No transfusion threshold defined
[21], Canada	Retrospective review	Pediatric patients with medulloblastoma treated with surgical resection followed by craniospinal irradiation +/- adjuvant chemotherapy	72	Not reported	Not reported	Local control Survival (2-, 5- and 10-year)	Reviewed relationship between Hb levels (threshold of 10.0 g/dL) and RT response, local control and survival in patients medulloblastoma.	Posterior fossa relapse occurred in patients who did not undergo total resection; no difference in local control or survival for patients with Hb below or above 10.0 g/dL during RT.	Only four patients were transfused; small sample size
[12], Canada	Retrospective review	Patients with cervical carcinoma (Stage IB, II, III or IVA) treated with radical RT	605	56 (mean)	41 (median)	OS Disease-free survival Pelvic (local) control analyses	Reviewed effect of Hb level [defined thresholds of 10.0 /dL ($n = 2$), 11.0 g/dL ($n = 1$) and 12.0 g/dL ($n = 2$) in 4/7 sites] and transfusions in RT	Suggest average weekly nadir Hb is predictive of outcome (second to disease stage in prognostic significance); Hb level was significant on univariate analysis (not multivariate analysis); increase in OS with increasing Hb from < 11.0 g/dL to > 12.0 g/dL whether achieved via transfusion or spontaneously; Hb level > 13.0 g/dL not associated with additional survival gain	Over 3 years of study, number of patients who received transfusions decreased in subgroup of 4 centers with transfusion policies.
[13], Austria	Retrospective review	Patients with cervical cancer (IB, II, IIIB, IV) treated with radical RT (including external beam irradiation and brachytherapy)	204	66 (median)	48 (median)	DSS Pelvic control MFS	Reviewed effect of transfusion for Hb < 11.0 g/dL versus no transfusion in cervical cancer	Outcomes for transfused and non-transfused patients did not differ significantly; DSS, pelvic control and metastases-free survival decreased in patients not responding to transfusion ($p < 0.001$)	Subgroup analysis suggests etiology of anemia should be further investigated given lack of prognostic impact of transfusion on patients with anemia from other comorbidities

(*continued on next page*)

Table 1 (*continued*)

Author, year, country	Study design	Setting, participants	Sample size, n	Age, years	Follow up, months	Outcome assessed	What was studied	Major findings	Comment
[15], USA	Retrospective review	Patients with cervical cancer (IIB, III) treated with external radiation and intracavitary brachytherapy +/- platinum	130	51 (transfused), 56 (non-transfused)	50 months (median) for transfused, 49 months (median) for not transfused	OS	Compared anemic patients who were transfused to not transfused	OS of transfused patients significantly lower versus patients not transfused after adjusting for age, no chemotherapy and histology	
[17], Canada	Retrospective review	Patients with unresectable esophageal cancer treated with RT and concurrent cisplatin and 5-fluorouracil	56	Not reported	62 (median)	OS RFS	Reviewed effect of transfusion for Hb < 12.0 g/dL versus no transfusion on survival in esophageal cancer	Transfusion associated with improved OS (OS was 65% versus 21% in patients treated with versus without a transfusion); no significant association between low pretreatment Hb and survival	Small sample size
Bhide et al., 2008, UK	Retrospective review	Patients with SCCHN treated with sequential CCRT	169	60 (median)	23.6	LRC RFS DSS OS	Reviewed incidence of anemia in patients treated with CCRT for locally advanced SCCHN, and examined effect of policy of Hb maintenance (threshold of 12.0 g/dL) by blood transfusion on LRC, DSS and OS	RFS, DSS and OS were better among patients not transfused versus those who were; Nadir Hb level > 12.0 g/dL and > 4 units transfused associated with worse LRC, RFS, DSS and OS	Study suggests transfusion during sequential treatment for SCCHN may be harmful
[16], South Korea	Retrospective review	Patients with cervical cancer (IIB) treated with RT +/- chemotherapy	119	60 (median)	39.3 (median)	OS MFS	Reviewed effect of transfusion for Hb < 10.0 g/dL versus no transfusion	Pre-treatment transfusion showed higher risk of distant metastases and lower OS compared to transfusion during RT	
[11], Denmark	RCT	Patients with SCCHN treated with RT	1166	Not reported	60 or death	LRC DSS OS	Stratified patients with SCCHN with low pre-radiation Hb levels (females < 13.0 g/dL and males < 14.5 g/dL) to RBC transfusion (235 patients) versus no transfusion (230 patients)	No significant differences between groups in locoregional disease control or overall survival after five years of follow up, despite increased Hb levels in the transfused group; patients with low baseline Hb had a decreased probability of LRC, DSS and OS	Pooled results from two RCTs
Tuan et al., 2013, UK	Retrospective review	Patients with esophageal cancer (Stage IIIA/B/C, IVA) treated with induction chemotherapy and RT	151	65 (non-anemic), 69 (anemic with transfusion), 71 (anemic without transfusion)	16.1 (median)	OS PFS LRFS	Reviewed survival among patients who were not anemic, anemic with transfusion and anemic without transfusion based on threshold of Hb < 12 g/dL	Multivariate analysis demonstrated that anemic patients transfused had improved OS, DFS and LRFS versus non-transfused patients	Small sample

Abbreviations: CCRT, chemotherapy followed by concomitant chemoradiation; DSS, disease-specific site; Hb, hemoglobin; LRC, locoregional control; LRFS, locoregional recurrence-free survival; MFS, metastases-free survival; OS, overall survival; PFS, progression-free survival; RCT, randomized controlled trial; RFS, relapse-free survival; RT, radiotherapy; SCCHN, squamous cell cancer of the head and neck; TURP, transurethral resection of the prostate.

transfused at a Hb level ≤ 11 g/dL [13]. The study found that patients whose Hb was normalized with RBC transfusion had similar disease-specific survival rates to non-anemic patients; patients whose Hb did not respond to transfusion had poorer survival rates (RR 2.1; 95% CI: 1.2–3.4). A French retrospective cohort found a similar increased risk of locoregional and distant disease relapse in anemic patients with cervical cancer in a univariate analysis (RR 1.8; $p < 0.01$); this was not maintained in multivariate analysis (RR 1.1; p = NS [not reported]) [14]. Patients who were transfused had worse outcomes in univariate analysis ($p < 0.01$), but this was not replicated in multivariate analysis (p = NS [not reported]). Neither anemia nor transfusion were independent predictors of outcome in multivariate analyses from this cohort. A retrospective study from Arkansas showed that transfusion (suggested for Hb < 10.5 g/dL) was associated with significantly reduced overall survival among patients with cervical cancer in multivariate analysis [15].

Some studies evaluated Hb levels pre-treatment and during treatment [12]. A retrospective Korean study assessed the effects of timing of RBC transfusion in 119 cervical cancer patients transfused to maintain Hb levels > 10 g/dL [16]. Among 32 patients who received packed red blood cell transfusion before or during radiotherapy, the study found reduced overall survival in patients who were anemic prior to treatment ($n = 18$, $p = 0.032$), but not during treatment ($n = 13$, $p = 0.42$). Pre-treatment transfusion was associated with reduced overall survival in multivariate analysis ($p = 0.031$), but not average weekly nadir Hb during treatment ($p = 0.948$).

In addition to the Danish RCT, head and neck cancer patients treated with radiation have been assessed in retrospective cohort studies. A study of 56 patients from British Columbia without a standardized transfusion protocol found increased five-year overall survival in patients who were transfused compared to those who were not (65% vs 21%; $p = 0.006$) [17]. In multivariate Cox regression, transfusion was associated with improved overall survival ($p = 0.013$), but Hb was not ($p = 0.55$). This is the only published study to suggest that outcomes in patients treated with blood transfusions are superior to those of non-anemic patients not requiring transfusion.

A British study assessing 169 patients with HNSCC who were transfused for Hb < 12 g/dL showed a significant reduction in overall survival in transfused patients ($p = 0.005$) and in those who received > 4 units ($p < 0.001$) [18]. Another study from the same institution included patients with all subtypes of esophageal cancer compared those who were anemic and transfused versus those who were not transfused despite meeting local center transfusion criteria [19]. The study found reduced overall survival ($p = 0.007$), and no difference in locoregional control ($p = 0.25$) in patients who were not transfused despite being anemic, compared to patients who were transfused when anemic and patients who were not anemic. A multivariate analysis showed worse survival ($p = 0.003$) and locoregional control ($p = 0.025$) in the anemic group that was not transfused compared to the group that was transfused.

While most published studies evaluated cervical and head and neck cancers, retrospective studies have assessed other disease sites. A British cohort of 71 patients with prostate cancer treated with RT after transurethral resection of prostate (TURP) showed significantly improved five-year survival in non-transfused patients (66% vs 17%, $p < 0.001$) [20]. RBC transfusion thresholds were not standardized in this study. A Canadian pediatric retrospective cohort of 72 patients with medulloblastoma treated with surgical resection followed by brain irradiation showed similar relapse rates, locoregional disease control and overall survival in patients with Hb below and above 10 g/dL during RT [21]. Due to the small sample size and low number of transfused patients ($n = 4$), the study could not rule out possible benefits of improving anemia using RBC transfusion before RT.

Discussion

We identified a single interventional trial in head and neck cancer (DAHANCA 5 & 7) comparing different Hb transfusion thresholds [11]. This is the most robust study available showing that transfusion does not lead to improved outcomes in patients undergoing RT. The remainder of the published literature in this area comprises observational, retrospective studies from a variety of cancer subtypes. Of the 10 retrospective studies included in our review, there was no common transfusion threshold evaluated, and thresholds ranged from 10 to 14.5 g/dL. Study results demonstrated no consistent conclusions regarding whether blood transfusions around the time of RT improve or worsen outcomes such as locoregional control and overall survival. It is unclear whether Hb targets are generalizable between disease sites given the unique histology of each cancer type.

The single interventional trial included in our study has important limitations. The Hb thresholds used may not be generalizable as they are not concordant with conventional Hb reference ranges in North America, such as the World Health Organization/National Cancer Institute's criteria for anemia in women and men (< 12.0 g/dL and < 14.0 g/dL, respectively) [22]. With known risks of transfusion and literature supporting conservative transfusion strategies in many other clinical scenarios, few providers would be comfortable transfusing patients at normal or near normal Hb levels [3,23]. By including patients who were not necessarily anemic in the low Hb group (i.e., women with Hb ≥ 12.0 g/dL, but < 13.0 g/dL), the study may have masked potential benefits that RBC transfusions have in patients with significant anemia. Because the DAHANCA trials pooled patients from two studies with different interventions, the individual study populations may not represent a homogenous group that can be analyzed together. Major limitations of the retrospective observational studies described in the narrative review include small sample sizes, lack of correlation between transfusion and Hb levels and low external and internal validity.

There is discordance in published literature on the effects of anemia and transfusion on outcomes in radiation oncology patients even after regression analyses to isolate the effects of anemia [12,24,25]. Studies of cervical cancer patients with anemia, which comprise mostly non-interventional retrospective studies, have had varying outcomes. These data suggest anemia is associated with poor prognosis (e.g., increased locoregional recurrence), but do not conclusively demonstrate causation or that poor prognosis can be overcome by transfusion. In addition to impaired tumor response to RT via reduced reactive oxygen species, other proposed mechanisms of hypoxia-related RT resistance include increased numbers of cells in the G_0/non-cycling phase of mitosis and proteomic/genomic alterations leading to decreased apoptosis and increased DNA repair [26,27]. Anemia may also be a tumor-related marker of poor prognosis that cannot be overcome by administering blood transfusion to increase Hb levels.

In most studies, transfusion is a surrogate outcome for anemia, which may independently affect key outcomes of interest including overall survival. The use of RBC transfusions may increase overall tissue oxygen tension and improve the radio-sensitivity of target tissues without requiring increased doses of radiation. A recent study in HNSCC suggests that transfusion does not reduce tumour hypoxia in vivo, as assessed by magnetic resonance imaging and the presence of hypoxic cytokines [28]. Even using regression analyses, non-interventional retrospective studies cannot adequately assess whether correction of anemia can overcome its negative prognostic effects, nor can they identify optimal Hb transfusion thresholds.

It has been hypothesized that erythropoiesis-stimulating agents (ESAs) might reduce tumor hypoxia by increasing Hb levels, thereby improving response to RT. However, interventional trial safety data have suggested that ESAs might adversely affect outcomes in certain cancer patients including overall survival [29]. ESAs have been shown to lead to worse locoregional progression-free survival in head and neck cancer, likely due to the expression of erythropoietin receptors on tumor cells [30]. Furthermore, ESAs have been associated with disproportionately high Hb levels and increased thromboembolic complications, which may lead to worse cancer outcomes and possibly inferior survival [29,31,32]. For this reason, current guidelines suggest that ESAs should

not be offered to most patients with anemia during malignancy [32].

Few studies to date have adequately assessed the potential deleterious effects of transfusions in cancer patients treated with radiation. Conventional transfusion reactions including hemolysis, transfusion-related acute lung injury, transfusion-associated circulatory overload, allergic reactions and infectious complications may cause significant mortality and morbidity. In addition, it has been hypothesized that allogeneic RBC blood transfusions can have a variety of immunomodulating effects [33]. Effects of allogeneic transfusions may be mediated by residual donor white blood cells, soluble cytokines and the presence of unrecognized HLA antigens. More studies are needed to examine whether these interactions lead to deleterious oncologic outcomes in the setting of radiation treatments.

Well-designed prospective, interventional studies are urgently needed to assess the role of blood transfusions in cancer patients receiving radiation. Given the unique radiobiology of different cancer histologies, it remains unclear whether transfusion thresholds can be generalized to all patients. Future studies would ideally compare different transfusion strategies using a prospective RCT design. It is the authors' view that a trial design comparing a conventional transfusion threshold (7–8 g/dL) to a higher Hb threshold for transfusion ($\geq$ 9-10 g/dL) would have clinical equipoise. Any trial should involve both radiation oncologists and transfusion medicine specialists to highlight their unique perspectives in improving patient outcomes. Well-conducted retrospective observational studies may also be useful.

Conclusion

Optimal transfusion practice in radiation oncology is unclear with no high-quality data to guide clinical practice. To date, there is no conclusive evidence that transfusion outside of thresholds conventionally applied in clinical settings is associated with improved outcomes. It remains unclear whether transfusion thresholds should differ between different cancer disease sites.

Patient Consent Statement

No patient consent was required in the collection and interpretation of data for this manuscript.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1. . Systematic review search strategies in PubMed (Medline), EMBASE and the Cochrane database of systematic reviews

PubMed (Medline) search strategy:
(hgb[tw] OR hemotherapy[tw] OR red blood cell*[tw] OR Eryhem[tw] OR hemoglobin*[tw] OR haemoglobin*[tw] OR hemoglobins[mh] OR blood transfusion[mh] OR transfusion*[tw] OR hematocrit[tw])
AND
(radiotherapy[mh] OR irradiation[tw] OR radiotherapy[tw] OR radiation[tw])
AND
cancer[sb]
Limits: Humans
Results: 4585
EMBASE search strategy: ~~(RIS 63–75)~~
exp hemoglobin/ or hgb.mp. or hemotherapy.mp. or exp blood transfusion/ or red blood cell*.mp. or Eryhem.mp. or hemoglobin*.mp. or haemoglobin*.mp. or transfusion*.mp. or hematocrit.mp. or exp hematocrit/
and
radiotherapy.mp. or exp radiotherapy/ or irradiation.mp. or exp irradiation/ or exp radiation/ or radiation.mp.
and
oncology.mp. or exp oncology/ or cancer.mp. or exp malignant neoplasm/
Limits: (human and exclude medline journals)
Results: 1256
Cochrane Database of Systematic Reviews strategy: ~~(RIS 76–83)~~
hgb.mp. or hemotherapy.mp. or red blood cell*.mp. or Eryhem.mp. or hemoglobin*.mp. or haemoglobin*.mp. or hemoglobins.mp. or blood transfusion.mp. or transfusion*.mp. or hematocrit.mp.
[mp = ti, ot, ab, tx, kw, ct, sh, hw]
and
radiotherapy.mp. or irradiation.mp. or radiation.mp. [mp = ti, ot, ab, tx, kw, ct, sh, hw]
and
(cancer or oncology or neoplasms).mp. [mp = ti, ot, ab, tx, kw, ct, sh, hw]
Limit: Humans
Results: 614

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