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Original Article

Radiotherapy for Oesophageal Cancer in the United Kingdom: Patterns of Practice and Quality Indicators

C.W. Bleaney [*†], K. Aitken [‡], T.D.L. Crosby [§], G. Radhakrishna [*†], R. Roy [¶], K. Spencer [‖], C.M. Jones [**††]

[*] Faculty of Biology, Medicine & Health, University of Manchester, Manchester, UK
[†] Christie Hospital, The Christie NHS Foundation Trust, Manchester, UK
[‡] The Royal Marsden NHS Foundation Trust, London, UK
[§] Velindre Cancer Centre, Velindre University NHS Trust, Cardiff, UK
[¶] Queen's Centre for Oncology & Haematology, Hull University Hospitals NHS Trust, Hull, UK
[‖] Leeds Institute of Health Sciences, University of Leeds, Leeds, UK
[**] Department of Oncology, University of Cambridge, Cambridge, UK
[††] Addenbrooke's Hospital, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK

Abstract

Aims: There is limited guidance relating to the provision of radiotherapy for patients with oesophageal cancer. Given this, we sought to assess variation in patterns of care in the UK and to devise quality improvement metrics to support future treatment standardisation.
Materials and Methods: We undertook a cross-sectional survey using a bespoke online survey to explore geographical variation in radiotherapy use for oesophageal cancer across the United Kingdom (UK) National Health Service (NHS). These data were combined with an observational registry analysis using the National Disease Registration Service Radiotherapy Dataset to explore temporal variation in radiotherapy utilization from January 2020 – June 2024.
Results: Survey responses were received from 75% (n = 45/60) of UK centres. These demonstrate considerable variation in the interpretation of radiotherapy indications, particularly in the non-curative setting, as well as in radiotherapy technique; with, for instance, one third (n = 15/45) of centres reporting that they do not use motion management strategies for lower third or junctional tumours. Induction chemotherapy use differs between centres and by concurrent regimen, with 93–96% (n = 42–43/45) of centres using induction treatment prior to concurrent platinum/fluoropyrimidine and 56–62% (n = 25–28/45) using it prior to concurrent platinum/taxane. Post-treatment surveillance and follow-up measures also differed with little evidence for more intensive surveillance in patients fit for salvage resection. Most centres reported the use of intensity modulated or volumetric arc therapy (IMRT/VMAT) for radical plans, which was supported by NDRS data demonstrating that the median proportion of patients in each centre treated using IMRT/VMAT increased from 60% (range 14.3–100%) in January-June 2020 to 91.7% (range 16.7–100%) in January-June 2024.
Conclusions: There is substantial variation in the radiotherapy-based care of patients with oesophageal cancer in the UK. Formal national guidance is required to build on the quality metrics outlined here.

Key words: Oesophageal; oesophageal squamous-cell carcinoma; outcomes; radiotherapy; standardisation; variation

Background

Oesophageal cancer is a major global cause of morbidity and mortality, accounting each year for 13 million disability adjusted life years and 356,000 deaths [1]. There are two predominant histological subtypes; oesophageal squamous cell carcinoma (OSCC) and oesophageal adenocarcinoma (OAC) [2]. OSCC accounts for up to 90% of cases of oesophageal cancer worldwide but the incidence of OAC has increased markedly in higher income countries over recent decades and it is now the predominant subtype in the United Kingdom (UK) and multiple other countries within North America, Europe and Australasia [3]. Highlighting the impact of these trends, recent projections suggest that by 2032 the male and female age-standardised rate for OAC in England will reach 16.2 and 4.0 cases per

Address for correspondence: Christopher M. Jones, Early Cancer Institute, Cambridge Biomedical Campus, University of Cambridge, Cambridge, CB2 0XZ, UK.
E-mail address: cj480@cam.ac.uk (C.M. Jones).

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100,000, respectively, compared with rates of 4.6 and 3.5 cases of OSCC per 100,000, respectively [4].

Radiotherapy is an important treatment for patients diagnosed with oesophageal cancer and is used in around half of cases worldwide [5]. It can be delivered using an external-beam or as endoluminal brachytherapy and has roles across curative and palliative settings [2]. However, for those with locally advanced disease, indications for radiotherapy increasingly differ by tumour subtype [2]. In OSCC, neoadjuvant chemoradiotherapy (CRT), surgery and adjuvant immune checkpoint inhibition for those without a pathological complete response is regarded as an equivalent standard of care to definitive CRT and close surveillance for the radical treatment of patients with locally advanced disease [2]. In contrast, data from the ESOPEC trial suggest that neoadjuvant CRT is inferior to perioperative triplet 5-fluorouracil/leucovorin, oxaliplatin and docetaxel (FLOT) chemotherapy with resection in the setting of locally advanced OAC, albeit in a study with no prospective radiotherapy quality assurance, inadequate staging and a high metastatic burden at baseline [6]. Nevertheless, definitive CRT retains a role for those unfit for or unwilling to undergo an oesophagectomy, though the extent to which it is used in this context is not known [7]. There is also uncertainty relating to perspectives on the indications for radiotherapy in the palliative setting, particularly given that the ROCS trial has recently demonstrated no additional benefit from radiotherapy use in patients who had received a self-expanding metal stent for dysphagia [8].

Despite these challenges to the role of radiotherapy in oesophageal cancer, recent decades have seen multiple advances in its deployment. This includes the advent of intensity-modulated techniques and improved motion management strategies, the use of image guidance and enhanced multidisciplinary team support [9]. There is in addition an increasing recognition of the importance of systemic therapy to delivering improved outcomes and of the potential benefits that may be afforded by early treatment of recurrence following definitive CRT [10–13].

The extent to which these developments impact clinical practice in the UK is unclear and there is limited national guidance to ensure that treatment aligns with an evolving evidence base. There is, for example, relatively little information relating to radiotherapy in relevant National Institute for Health & Clinical Excellence (NICE; NG83) and European Society for Medical Oncology Clinical Practice Guidelines [14,15]. Further, radiotherapy-orientated guidelines published by the Royal College of Radiologists extend only to suggested dose and fractionation schedules, along with recommendations for implementing image guidance [16,17]. These together highlight significant potential for variation in care but existing relevant analyses, such as that undertaken by the National Oesophagogastric Cancer Audit (NOGCA), lack sufficient granularity to evaluate this [18].

We therefore sought to evaluate reported patterns of practice in the delivery of radiotherapy for oesophageal cancer in the UK and to compare this to temporal and geographic variation in practice gleaned from routinely-collated clinical data held by the National Disease Registration Service (NDRS) Radiotherapy Data Set (RTDS).

Methods

Study Design

This was a cross-sectional study of UK clinical oncologists with an interest in oesophagogastric cancer, in which we aimed to survey the current radiotherapy treatment practices of UK National Health Service (NHS) cancer centres. In doing so, we sought to obtain a single response representing the practice of each UK cancer centre at which radiotherapy is delivered. Separately, we undertook an observational registry data analysis to understand temporal variation in radiotherapy use for oesophageal cancers in the English NHS. This was enabled by a partnership between NDRS and NHS England's Specialized Commissioning Radiotherapy team, which brought together clinical oncologists with an interest in oesophageal cancer (KA, GR, RR, KS, CMJ) to support the development of draft quality improvement metrics. This was part of a process instigated by NHS England to reduce variation in the quality of radiotherapy delivered for multiple tumour types across English centres through developing metrics that would act as markers of quality in a future quality improvement toolkit. The resulting metrics were implemented using the National Radiotherapy Dataset (RTDS), collected and curated by the NDRS, providing the data reported here. Study-specific ethical approval was neither required nor requested.

Survey Instrument

An online survey was developed (available within Supplementary Materials) using the cloud-based software provider, SurveyMonkey (SurveyMonkey Inc., California, USA). The scope of the survey was set by the authors and encompassed questions relating to the indications for radiotherapy use in OAC. This was felt to be of pertinence given that whilst definitive CRT is an established treatment option for unresectable, locally advanced OAC, NICE NG83 stipulates only that CRT use should be considered for patients with unresectable disease [14,15]. The approval in 2024 of first-line chemo-immunotherapy for untreated locally advanced unresectable OAC (TA737) provides an alternative option for clinicians but the extent to which this is used is unknown [19]. We also queried the mode of delivery of radiotherapy; including technique and use of image guidance, access to endoluminal brachytherapy, frequency of peer-review, subsequent requirement for replanning during treatment, and the involvement of the broader multidisciplinary team in radiotherapy-related care. Given the importance of an evolving evidence base to improved cancer care, the barriers and enablers to broader radiotherapy-related trial participation were additionally evaluated. The draft questionnaire was peer-

reviewed by two experienced consultant clinical oncologists who have a site-specialist interest in oesophageal cancer.

Study Population and Survey Dissemination

Consultant clinical oncologists who deliver treatment for oesophageal cancer were identified for 58 of 60 UK cancer centres that deliver radiotherapy using web searches and a contact list maintained by CMJ. Each identified clinician was emailed directly between July and November 2024 to ask them to complete the online survey. Two reminder emails were sent during this period to centres from which no response had been received.

Development of Quality Improvement Metrics

There are few quality indicators for radiotherapy in any site globally and there are no UK radiotherapy quality indicators for oesophageal cancer care, including within NOGCA [18,20]. Given this, NHS England's Specialised Commissioning Radiotherapy team formed a partnership with the NDRS RTDS to develop and implement a quality improvement toolkit, incorporating metrics from a range of tumour types, including oesophageal cancer. The oesophageal metrics were developed based on expert opinion in addition to the limited available guidance published by NICE and the RCR for UK radiotherapy practice in oesophageal cancer care [15–17]. Following discussion amongst the clinical expert group, metrics were developed that were felt to reflect current best practice for each area for which corresponding data were available within RTDS. This involved a series of meetings amongst the group to agree and ratify the metrics. The selected metrics are summarized in Table 2. Two metrics, assessable using the currently available RTDS (1a/b combined and 6, see Table 2), are included here (proportion of radical episodes for OG cancer delivered using IMRT and median wait from decision to treat/earliest clinically appropriate start date to treatment start date). Further metrics which rely upon the forthcoming version (v6) of the RTDS will be available via the NDRS in due course.

Analysis of Routinely Reported Data Using RTDS

To determine the potential utility of the initial two identified quality improvement metrics, we analysed variation in the proportion of English cancer centres adhering to the standards over six-monthly intervals from January 2020 to June 2024. Records for treatment episodes reported to the RTDS, delivered in English radiotherapy centres, with a clinician-specified curative intent for oesophago-gastric cancer (ICD10 codes C15-16) and with the first fraction delivered between Jan 1st, 2020 and Jun 30th, 2024, were included in metric analyses, alongside information regarding the use of IMRT, date of decision to treat (DTT)/earliest clinically appropriate date (ECAD) and the first fraction of each episode. The proportion of episodes delivered using IMRT in each radiotherapy centre was calculated, in addition to the median time from DTT/ECAD to treatment start, for six month periods by radiotherapy centre. The results of these analyses are available to NHS clinicians and providers in England (with additional supporting information) on the cancerstats website (cancerstats.ndrs.nhs.uk). Whilst radiotherapy data are collected in Wales and Scotland, these metrics were developed in partnership with NHS England and cannot be replicated in devolved nation data without appropriate approvals.

Data Analysis and Representation

Descriptive analyses of data are provided, with graphical illustrations generated using GraphPad Prism version 10.4.1 (GraphPad Software, California, USA). Sankey diagrams were generated using the open-source webpage, www.sankeymatic.com.

Results

Survey Response Rates

Responses were received from 75% (n = 45) of the 60 NHS cancer centres that provide radiotherapy in the UK, as summarized in Figure 1 and Supplementary Table 1. There is limited radiotherapy capacity in the UK outside of that offered by the NHS.

Indications for Radiotherapy

We queried the preferred first-line treatment approach for patients who present with locally advanced but inoperable OAC, for whom 95% (n = 39/41) of respondents reported that they would routinely use definitive CRT. Three respondents indicated in free text responses that in more advanced but still non-metastatic cases they would preferentially opt for first-line chemo-immunotherapy, with definitive CRT then used as a consolidation therapy in the presence of stable disease.

In the palliative setting, all respondents reported that they would consider radiotherapy for bleeding and 87% (n = 39/45) for each of dysphagia and pain. However, just 7% (n = 3/45) would consider radiotherapy alone for the management of dysphagia, with centres otherwise preferring to use radiotherapy in patients with reasonable swallow function and to proceed to stenting in cases of a poor, or acutely deteriorating, swallow. Overall, 78% (n = 35/45) would also use radiotherapy for local control, though the consensus from free text responses was that this would be considered only in the context of stable systemic disease.

Overall Treatment Approach

The use of cytotoxic chemotherapy as an induction treatment prior to definitive CRT for patients with locally advanced disease varies between centres and by the

planned concurrent chemotherapy regimen, with no clear difference between histological subtypes. For patients planned to receive a platinum/fluoropyrimidine doublet concurrent with radiotherapy, 93% (n = 42/45) and 96% (n = 43/45) of centres reported that they would sometimes or always deliver induction chemotherapy for OAC and OSCC, respectively. However, for those planned to receive concurrent doublet platinum/taxane, only 56% (n = 25/45) and 62% (n = 28/45) of centres would sometimes or always respectively deliver induction chemotherapy for OAC and OSCC. As shown in Figure 2A, the chemotherapy agent used for induction therapy varies by centre, with for instance a small proportion electing to routinely or always administer induction platinum/5-fluorouracil in patients planned to receive concurrent platinum/taxane.

Radiotherapy Approach, Technique and Quality Assurance

The use of radiotherapy peer-review in the potentially curative setting varied between centres and by planning stage. All centres peer-reviewed contours, though 24% (n = 11/45) only did so on an *ad hoc* basis. By contrast, only 82% (n = 37/45) reviewed radiotherapy plans, and a majority (62% n = 23/37) did so on an *ad hoc* basis. All but one (98%; n = 44/45) of the studied centres routinely deliver IMRT or rotational arc therapy for patients with potentially curable disease, with the remaining centre maintaining a 3D conformal approach. However, as outlined in Figure 2E, one third (n = 15/45) of centres do not use motion management strategies for lower-third or gastroesophageal junctional (GOJ) tumours. Of those that do account for motion, over two thirds (71%; n = 32/45) employ motion encompassing techniques such as 4D planning with motion tracking or suppression used infrequently.

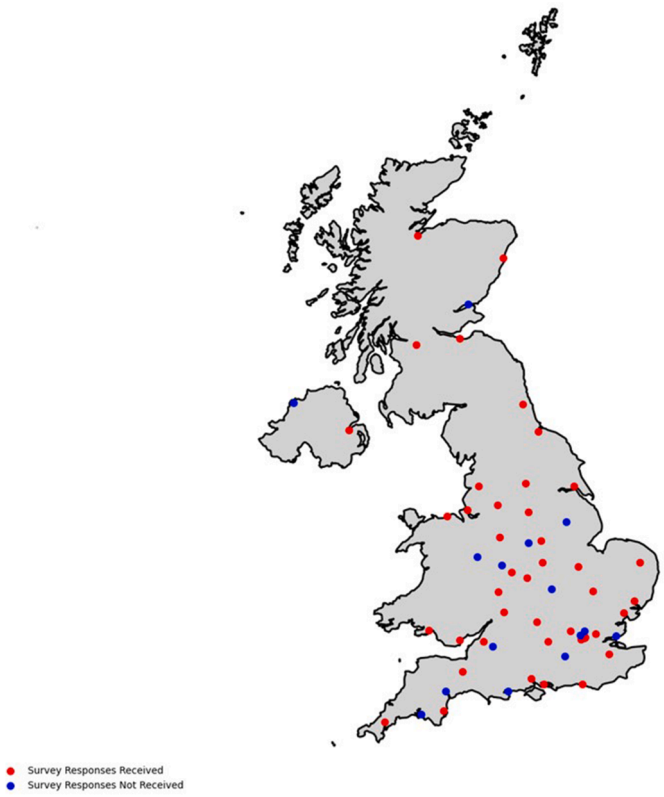

Fig 1. A summary of UK National Health Service centres that responded to the survey. Responding centres are shown in red.

A majority (91%; n = 41/45) of centres use image guidance daily throughout treatment or daily early in treatment and then less frequently thereafter (Figure 2F). There is nevertheless variability in the set-up error that would prompt a re-plan, albeit with a majority using an error of 5–10mm as their threshold (Figure 2G). Other reported factors that contribute to decisions to re-plan treatments are provided in Figure 2H. Once re-contoured, 42% (n = 19/45) centres implement new radiotherapy plans within 48 hours, though 20% (n = 9/45) of centres take more than 4 days (Figure 2I).

In the palliative setting, 58% (n = 26/45), 11% (n = 5/45) and 31% (n = 14/45) of centres respectively use 2D, 3D conformal and intensity modulated approaches for external beam treatments, which are most frequently (53%; n = 24/45) delivered at 20 Gy in 5 fractions (Figure 2J). Free text responses nevertheless suggested expected nuance in selection of dosing that is based on patient fitness and indication, with a preference for a single 8 Gy fraction in instances of bleeding. Two thirds (67% n = 30/45) of centres do not have access to endoluminal brachytherapy, which is available at every opportunity for less than 10% (n = 4/45) of respondents (Figure 2K). The most common indications proffered for radiotherapy administered to patients receiving palliative systemic therapy was for symptom control (51%; 23/45) and consolidation in those who had responded well to pharmacological treatment (38%; n = 17/45). A far less common indication was for the treatment of bulky primary disease (9%; n = 4/45). Single centres offer upfront radiotherapy prior to systemic therapy and for patients poorly tolerant of systemic therapy. One centre reported that they would never provide radiotherapy for patients receiving palliative systemic therapy.

Multidisciplinary Team Contribution to the Care of Patients Receiving Radiotherapy

A majority (7%; n = 32/45) of centres do not offer prehabilitation for patients planned to receive definitive CRT, with only 9% (n = 4/45) offering this routinely and the remainder (20%; n = 9/45) offering it occasionally. As summarized in Table 1, there is then considerable variability in the frequency of contact between members of the multidisciplinary team and patients who are receiving definitive CRT. Nevertheless, patients have access to a clinical nurse specialist in all but one centre and to a doctor in all centres, albeit on an *ad hoc* basis rather than via preplanned review in 18% (n = 8/45) of centres.

Response Assessment and Post-treatment Follow-Up

As with prehabilitation, most (69%; n = 31/45) centres do not offer post-treatment rehabilitation, which was

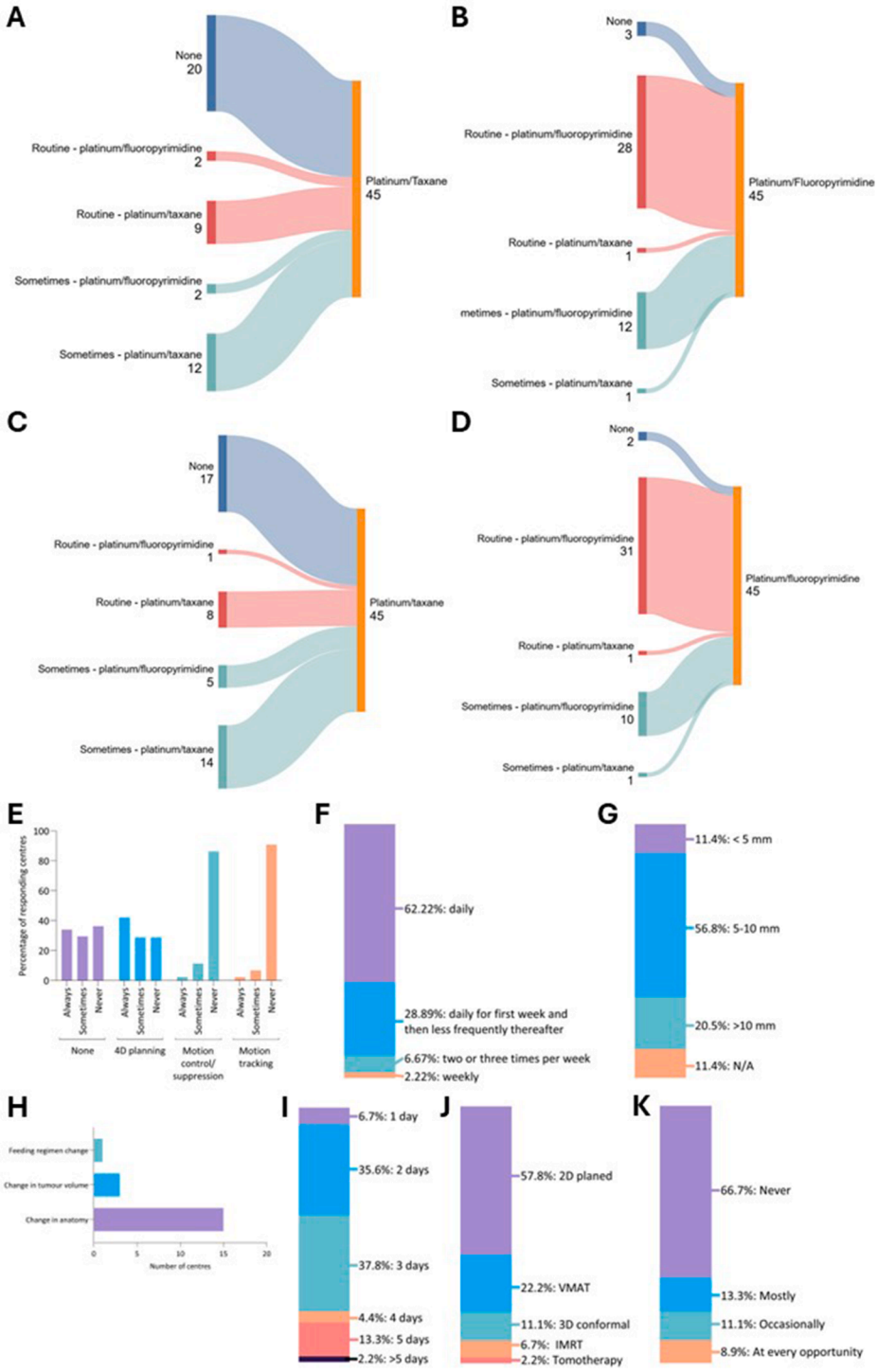

Fig 2. Treatment approaches for patients with potentially curable (A-I) or incurable (J-K) disease. **(A-D)** Choice of induction chemotherapy agent for patients with oesophageal adenocarcinoma planned for **(A)** concurrent platinum/taxane or **(B)** concurrent platinum/fluoropyrimidine, as well as for patients with oesophageal squamous cell carcinoma planned for **(C)** concurrent platinum/taxane or **(D)** concurrent platinum/fluoropyrimidine. **(E)** A summary of motion management techniques used for lower third or gastro-oesophageal junctional tumours. **(F)** Frequency of image guidance. **(G, H)** A summary of **(G)** set-up error margins and **(H)** other themes that clinicians state would result in them replanning treatment. **(I)** Average time (working days) for a re-plan to be achieved where required. **(J)** Typical palliative radiotherapy technique. **(K)** Access to brachytherapy for salvage and palliative boost therapy. Sankey diagrams were generated using www.sankeymatic.com.

available routinely in one and on occasion in thirteen (29%) centres. There is then considerable variation in approach to post-treatment response assessment, as outlined in Figure 3. Fewer than half (38%; n = 17/45) routinely undertake post-treatment endoscopy and biopsy for response assessments, with 13% (n = 6/45) reporting that they never do this. In contrast, all but one centre (98%; n = 44/45) perform post-treatment CT imaging for at least some patients. Magnetic resonance imaging (MRI) and positron emission tomography (PET)-CT were used far less frequently, with no routine use of the former.

Surveillance strategies also varied considerably across centres and by potential for salvage therapies in those with a favourable post-treatment response (Figure 3, Supp Table 2). For patients not considered to be candidates for salvage, most (80%; n = 36/45) centres offered routine monitoring for five years following treatment, though almost a tenth (9%; n = 4/45) were discharged within one year. Follow-up frequency then reduced markedly from 3 to 4 monthly for a majority in the first (91%; n = 41/45) and second (61%; n = 27/44) year to biannually for a majority in the third (77%; n = 34/44) and fourth (50%; n = 21/42) years, and at a one year interval for most (60%; n = 25/42) in the fifth year. CT imaging was used in just over half (60%; n = 27/45) of centres in the first year of surveillance but much less frequently thereafter, with few centres routinely undertaking endoscopy and biopsy or using other imaging modalities. By contrast, surveillance for potential salvage candidates was more frequent in a majority of centres and used more frequent CT imaging, albeit with endoscopy and biopsy assessments undertaken in only 60% (n = 27/45) in the first year and in 51% (n = 23/45) in the second year. All but two centres confirmed that they would welcome clinical practice guidelines for the follow-up of patients who have received definitive CRT.

Trials Participation

The UK has made significant contributions to the evidence base for the use of radiotherapy in oesophageal cancer across curative and palliative settings [8,12,21–24]. More recent trials have nevertheless accrued at a slower than planned rate [21]. Given this, we sought to identify hurdles to participation in radiotherapy-related oesophageal cancer trials. As summarized in Figure 4A, only 37% (n = 16/43) of centres took part in these at every opportunity, with 7% (n = 3/43) never partaking. Reported barriers to participation mostly centred around poor availability of support staff and insufficient capacity within the physician's job plan (Figure 4B).

Quality Improvement Metrics

Quality improvement metrics were studied using data from RTDS. During the study period, there was missing data within RTDS for 10% of a six-month submission period (August–December 2023) for a single provider that ordinarily accounts for 3–4% of all UK radiotherapy episodes. This data impacted on the studied periods of January 2023 to June 2023, and July 2023 to December 2023, albeit minimally. Incorrect coding was also provided for a single provider that accounts for around 6.5% of national episodes for the period of May to August 2024. Regardless of these caveats, the quality improvement metrics show variation between centres, as summarized in Figures 4C and D. Overall, the proportion of radical episodes delivered using IMRT or VMAT for each centre increased from a median of 60% (range 14.3–100%) in January–June 2020 to a median of 91.7% (range 16.7–100%) in January-June 2024 (Figure 4C). The time from diagnosis to treatment also showed variation over time, improving from a median of 23.2 days (range 0.5–42.5 days) in January-June 2020 to 21.7 days (range 1.5–42.6 days) in July-December 2021, before falling again to a median of 26.4 (0.7–41.5 days) days by January–June 2024.

Discussion

There is minimal guidance concerning the provision of radiotherapy for oesophageal cancers in the UK. This study draws on an observational registry analysis of routinely collated data submitted by all English NHS centres and a bespoke cross-sectional survey covering 75% of all UK NHS centres to demonstrate considerable variation in radiotherapy application and the wider care of patients treated using it. This diversity is exemplified by differences in the interpretation of indications for radiotherapy use in the palliative setting, in the variable use of induction chemotherapy prior to radical chemoradiotherapy, and in the inconsistent use of peer-review, motion management and image guidance techniques. Centres also differ markedly in the frequency with which patients are reviewed by different members of the cancer multidisciplinary team, median time to treatment start and in their use of post-

Table 1
Patient contact with members of the multidisciplinary team during definitive oesophageal chemoradiotherapy treatment

	Ad hoc only	> Weekly	Weekly	Fortnightly	< Fortnightly	Never
Doctor	8	1	20	10	5	0
Clinical nurse specialist	12	0	11	2	4	4
Radiographer	4	6	20	1	1	5
Dietician	18	0	2	0	2	9
Physician associate	1	0	0	1	0	29

Table 2
A summary of quality metrics based on existing standards within relevant National Institute for Health & Care Excellence and Royal College of Radiologists guidance. Metrics were developed for standards for which data were available within the National Cancer Registration and Analysis Service Radiotherapy Dataset (RTDS)

No.	Metric	Monitoring
1a	Use of IMRT for radical radiotherapy	Proportion of episodes using IMRT or VMAT.
1b	Use of VMAT for radical radiotherapy.	Proportion of episodes using VMAT.
2a	Use of image guidance during radical treatment.	Proportion of patients receiving IGRT for a minimum of the first three fractions of treatment and weekly thereafter.
2b	Use of image guidance during radical hypofractionated treatment.	Proportion of patients receiving hypofractionated (i.e. >2.4Gy per fraction) radiotherapy receiving daily IGRT.
2c	Use of image guidance during palliative radiotherapy.	Proportion of patients receiving IGRT on a minimum of the first three fractions of treatment and weekly thereafter.
3	Peer-review of radical cases.	Proportion of radical prescriptions that are prospectively peer-reviewed.
4a	Use of motion assessment during radical radiotherapy planning.	Proportion of treatments using 4DCT planning for radical intent treatment.
5a	Use of radical chemoradiotherapy or hypofractionated radiotherapy.	Proportion of patients treated with radical intent using either concurrent chemoradiotherapy or hypofractionated radiotherapy.
6	Time to start treatment	Days from decision to start treatment to the delivery of the first fraction of radiotherapy.

IGRT, image guidance radiotherapy; IMRT, intensity modulated radiotherapy; VMAT, volumetric arc therapy.

treatment follow-up and surveillance protocols. In contrast, most centres were united in not offering prehabilitation or rehabilitation.

The data outlined here build on existing evidence for variation in the care of patients with oesophagogastric cancer in the UK, as well as for the delivery of radiotherapy for other tumour sites. We have previously demonstrated substantial differences in the patient and disease characteristics that UK centres perceive as indications for endoscopic ultrasound to aid disease staging and treatment planning [25]. Others have shown considerable variation in the dose and fractionation schedules used to treat cervical oesophageal cancers [26]. These data are not unique to the UK. A 2024 analysis of population-level data in Norway, the four home UK nations, nine Canadian provinces and two Australian states demonstrated large interjurisdictional variation in radiotherapy use for oesophageal cancer [27]. Our findings are also not unique to oesophageal cancer care. There is longstanding evidence of considerable geographical variation in radiotherapy activity in the UK, as well as in the use of specific dose-fractionation patterns in other malignancies, such as surgically treated rectal cancers [28,29].

The geographical differences in radiotherapy-based treatment approaches for oesophageal cancers that are detailed here are nevertheless remarkable for the extent to which they outline variation at every step of the radiotherapy pathway. This variation includes differences in the use of radiotherapy for those with non-curative disease, for whom it is employed for local control in only three quarters of centres. This is likely to reflect a lack of high-level evidence for radiotherapy use in this context, albeit with a suggestion for benefit from retrospective series [30]. It is however noteworthy that despite the advent and approval of chemoimmunotherapy regimens for unresectable locally advanced OAC, practically all centres continue to advocate for the first-line use of definitive chemoradiotherapy in this context.

The data outlined here also suggest that not all centres routinely offer induction chemotherapy prior to definitive chemoradiotherapy, and that induction chemotherapy is less likely to be prescribed for those planned for concurrent platinum/taxane than for platinum/fluoropyrimidine. This variable practice may well contribute to at least some of the considerable variation in the time from a treatment decision to treatment start that is seen in the NDRS data. There is mixed evidence relating to whether induction chemotherapy offers a benefit for those planned for chemoradiotherapy but there is questionable rationale for offering an induction regimen in the context of planned concurrent platinum/fluoropyrimidine but not for planned concurrent platinum/taxane [7,31,32]. It is in addition disappointing that a third of centres do not offer motion management strategies for lower third and junctional tumours, despite evidence that 4DCT use results in a smaller planning target volume and lower dose levels for radiotherapy constraints [33]. On the other hand, it is reassuring that most centres are frequently employing image-guided radiotherapy to reduce interfractional variation and that an increasing proportion of patients are receiving treatment using an IMRT plan.

It is striking that less than 10% of centres responding to our survey had access to brachytherapy at every opportunity and that two thirds had no access at all. We have previously shown that brachytherapy achieves good outcomes as a salvage therapy following definitive chemoradiotherapy or as a local boost for patients receiving palliative radiotherapy [34]. This therefore suggests that patient outcomes could be readily improved by encouraging and facilitating the wider adoption of brachytherapy

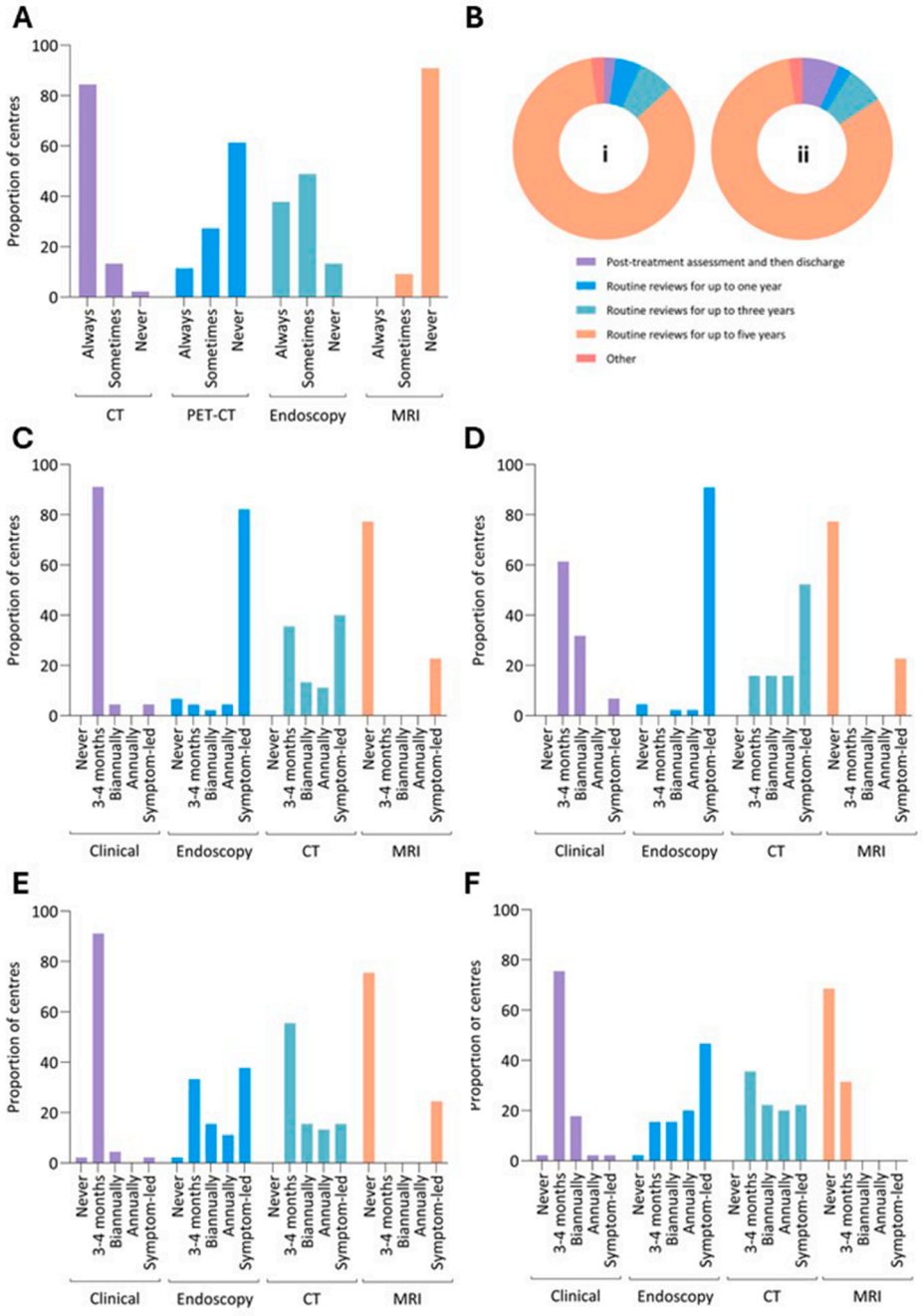

Fig 3. A summary of post-radiotherapy surveillance regimes in those with potentially curable disease. (**A**) Imaging modalities used for post-treatment response assessment. **(B)** Approach to the post-treatment follow-up of patients who have a favourable response to definitive chemoradiotherapy and who are **(i)** fit for or **(ii)** not fit for salvage resection. **(C,D)** Frequency of follow-up assessment and investigation at **(C)** year 1 and **(D)** year 2 following definitive chemoradiotherapy in patients considered unlikely to be fit for salvage resection. **(E, F)** Frequency of follow-up assessment and investigation at **(E)** year 1 and **(F)** year 2 following definitive chemoradiotherapy in patients considered to be fit for salvage resection.

for oesophageal cancer management. It is also notable that physician capacity and poor availability of support staff are resulting in only 37% of centres taking part in radiotherapy trials at every opportunity. This is despite the known benefits of trial recruitment in driving developments in oesophagogastric cancer radiotherapy in the UK [35].

Finally, the variation in follow-up regimes again likely reflects a previous lack of high-quality evidence. Recent data from the SANO trial nevertheless suggest reasonable outcomes from upfront chemoradiotherapy and salvage resection, which alongside other data points to potential benefit from closer follow-up of those who are fit for an oesophagectomy [36,37]. Furthermore, there are emerging data in OSCC for a benefit from the radical endoscopic treatment of local recurrence post-chemoradiotherapy in those not fit for resection as well as for early, aggressive,

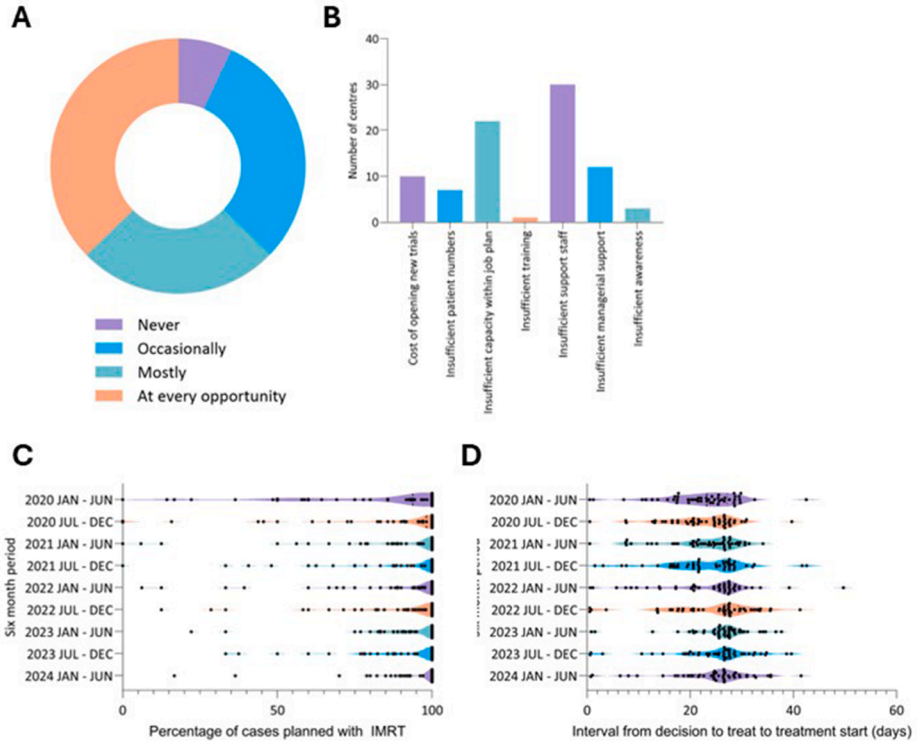

Fig 4. Building and auditing the evidence base for radiotherapy in oesophageal cancer care. **(A)** The proportion of centres reporting that they participate in studies focussed on radiotherapy for oesophageal cancer. **(B)** Barriers to participation in trials of radiotherapy use for oesophageal cancer care. **(C)** Variation in the proportion of cases planned with IMRT and **(D)** in the time from decision to treat to treatment start for each English National Health Service centre for six month intervals between January 2020 and June 2024.

management of oligometastatic disease [10,11]. Despite this, most centres appear to follow broadly similar surveillance regimes regardless of whether patients are fit for future salvage resection, and these appear in the main to employ infrequent clinical follow-up and even less frequent routine imaging across both contexts. There is in addition a greater reliance on CT surveillance when compared with endoscopies, including in the setting of patients fit for salvage resection, despite the known poor sensitivity of CT assessments in this context [38]. These data together point to a considerable risk that a lack of adequate guidance means that most UK centres are currently using surveillance regimes that risk missing an early recurrence in patients who may still be curable via a salvage surgical procedure.

Alongside these findings, a strength of this work is the analysis of newly derived quality improvement metrics using a robust routinely collated national dataset that allows for the analysis of changes in practice over time. It is reassuring that the data drawn from these metrics supports that deduced from the survey. Notwithstanding this, there are also limitations to our approach. It is not, for example, possible to conclude on the potential for the metrics devised here to influence radiotherapy care for patients with oesophageal cancer given that data were available via NDRS for only two of the quality standards. Future analyses will be required to assess the impact of these metrics. These nevertheless demonstrate considerable variation across centres and over time, such that they serve as a useful proof-of-principle for the use of these metrics to guide future analyses of radiotherapy care in the UK and support service improvement. Once data are available, analyses of the remaining quality improvement metrics (Table 2) will be undertaken by the RTDS team and results made available (https://digital.nhs.uk/ndrs/data/data-outputs/cancer-data-hub?area=treatment-data). It is notable that the NDRS analyses are limited to English data. Radiotherapy data are now collected in Wales and Scotland and we would encourage all devolved nations to consider implementing these metrics.

The survey data also has limitations. We did not receive survey responses from 25% of UK radiotherapy centres, which may expose the study to selection bias. However, as shown in Figure 1, these centres were not regionally clustered and, even if all 25% did offer standardised care, the variation in the other 75% remains concerning. It is also possible that there is variation in the care provided by clinicians within each centre such that we may not even have captured the full extent of the diversity of radiotherapy care provided for oesophageal cancer in the UK. Further, clinicians may be prone to recall bias and may overestimate their use of radiotherapy or their use of aspects such as peer review. It is, equally, possible that our data are confounded by a focus on clinical oncologists and that a survey of medical oncologists may have provided a higher estimate of the proportion of patients receiving

chemoimmunotherapy for locally advanced OAC. A number of the survey questions would also have benefited from greater granularity to allow respondents to justify and explain nuances in treatment approaches. It is possible, however, that this would have lowered the survey response rate given that there were already numerous relatively complex questions for each respondent to answer. Finally, the RTDS data are partly limited by incomplete returns from one provider and inaccurate coding from another. In reality, these affected a minor proportion of the studied data and are highly unlikely to have impacted the study conclusions.

This work has demonstrated a clear and unacceptable level of between-centre variation in the radiotherapy-based care of patients with oesophageal cancer. This highlights a need to urgently develop comprehensive national guidelines for the provision of radiotherapy in this context, and to continue to build on the quality metrics outlined here so that variation can be routinely audited and addressed in order to improve quality by delivering standardized, evidence-based care across all centres.

Author contributions

1. Guarantor of integrity of the entire study: Christopher M Jones
2. Study concepts and design: Christopher M Jones
3. Literature research: Christopher W Bleaney, Christopher M Jones, Katharine Aitken, Tom DL Crosby, Ganesh Radhakrishna, Rajarshi Roy, Katie Spencer
4. Clinical studies: N/A
5. Experimental studies/data analysis: Christopher W Bleaney, Christopher M Jones, Katharine Aitken, Tom DL Crosby, Ganesh Radhakrishna, Rajarshi Roy, Katie Spencer
6. Statistical analysis: Christopher W Bleaney, Katie Spencer, Christopher M Jones
7. Manuscript preparation: Christopher W Bleaney, Christopher M Jones
8. Manuscript editing: Christopher W Bleaney, Christopher M Jones, Katharine Aitken, Tom DL Crosby, Ganesh Radhakrishna, Rajarshi Roy, Katie Spencer

Conflict of Interest

The authors declare the following financial interests/personal relationships that may be considered as potential competing interests: Christopher Mark Jones reports a relationship with Candesic that includes: consulting or advisory. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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Appendix A. Supplementary data

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